THE ENGINEER.

Gear-Cutting Machines.

GEAR-CUTTING MACHINES.

TEN years ago, when the bicycle was at the height of its popularity, it stimulated an enormous trade in a certain class of machine tools. Had the bicycle not come, the mechanical engineer would likely enough have continued to the present day with tools of the type used by his grandfather. But it gave the machine tool maker an opportunity which he was not slow to take. There was a rush for certain classes of machines, and they could not be made fast enough to meet the demand for them. The cycle industry, after "booming," settled down to a steady pace. Then comes the motor car, and again the machine tool maker rises to the occasion; made the very tools that are wanted, and—in spite of what he says himself—reaps his reward.

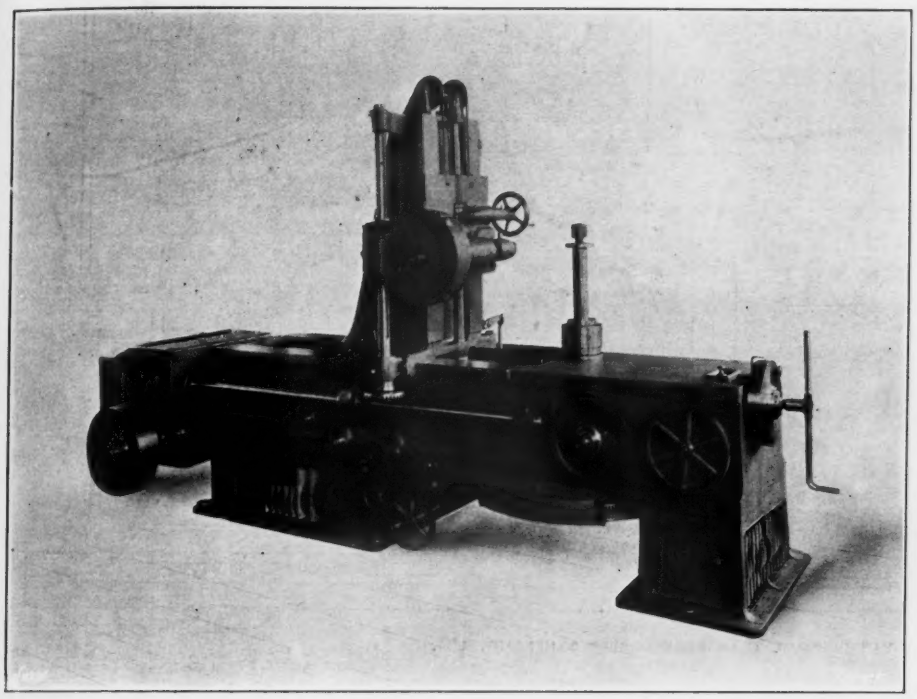


Fig. 1—6-FOOT GEAR-CUTTING MACHINE—CRAVEN BROS., LTD.

No motor car is without gearing of some kind, and no gearing of any kind works well if it is not well made. At first—the complaint has not yet been wholly removed—we had to tolerate a gear box that made a noise like a factory, but knowledge, skill, and, above all, excellent machines for the rapid and cheap production of accurate toothed wheels has changed, or is changing all that, and we now expect a box of gears to work so silently that it can only be heard when the ear is placed pretty close to it. For this perfection the motor car user has to thank the machine tool maker, who has exercised considerable ingenuity in providing a variety of machines that will produce almost perfect teeth on plain, bevel, helical, or worm wheels with a speed and precision that are quite remarkable. It is in view of the ever increasing use of this kind of machine that we have deemed the time appropriate to collect into a few pages descriptions of the principal types of gear cutters made in Germany, France, America, and, last but not least, in our own country. Several of the machines described will be recognised as old friends, others are fairly new, and many which are not new in their general features have by recent improvements been brought into line with the requirements of the day.

It will save a good deal of repetition if, before describing specific tools, we discuss the methods that may be employed to produce accurate spur teeth. If two sets of gear are to run smoothly together, the teeth must have certain specified forms. By a long way the most widely used tooth now-a-days is the involute. It is easy to draw, and easy to make, and a small error in the distance between two geared wheels does not affect the smoothness of the running. But whatever form of tooth is employed, certain essentials must be met if good workmanship and satisfactory results are sought. First the pitch must be absolutely accurate. Secondly, the shape of the tooth must be correct, and must be precisely the same on both sides, and, finally, the tooth must be placed in its correct position on the pitch line. The last is a matter of adjustment, the first depends on the accuracy of the machine tool, the second depends upon the shape of a cutter in milling, hobbing, and some shaping machines, and upon a former or model in other machines, whilst in one—the Robey-Smith—it is produced by a very elegant geometrical device. These remarks apply equally to all kinds of gear, but bevel and mitre wheels are complicated by the necessary taper form of the tooth. The beautiful devices which have been invented to produce a correct bevel tooth form a fascinating study.

The oldest and most obvious way of producing the tooth of a spur wheel is to mount the blank in a slotting or shaping machine, and use a tool formed precisely to the shape of the space between any two teeth. The next most obvious plan is to replace a reciprocating tool by a revolving one—that is, a milling cutter. If the milling cutter is properly made, there is probably no more accurate manner of producing a spur wheel than this. Several examples of such machines will be found in these pages. When we leave machines of these two types we pass from the obvious to the ingenious, and we find clever machines for hobbing spur wheels, or for producing them by the use of a highly specialised form of cutter, as on the Fellows machine. All the machines of this type depend upon an invaluable characteristic of the involute tooth, about which a few words must be said. This characteristic is that the involute rack tooth has straight sides. The flank of an involute tooth is struck with a radius equal to half the radius of the pitch circle. A rack may, of course, be regarded as a wheel of infinitely large radius, and, since half an infinitely long thing is still infinitely long, the radius for the flank is of infinite length, and the flank is, therefore, straight. Having this peculiarity, it will be seen that an involute rack will gear with all involute wheels, of no matter what diameter, having the same pitch. Could anything be better from the machinist's point of view? Let him convert his rack into a cutting tool, and harmonising its slotting motion with the correct speed of rotation of the blank, with one cutter he can produce a whole host of gears of different diameters. Moreover, since all these gears will gear with the same rack, they will all gear together. Really, when we consider this obliging nature of the involute tooth we cannot but feel that it is doing its best to make things easy for the machine tool maker.

In the gear hobbing machine, in place of a slotting motion, we have a rotary and continuous action, but the principle is precisely the same. The hob has flat-sided teeth, arranged in a spiral of the proper pitch, and it is tilted longitudinally when cutting straight teeth to the same angle as its pitch—that is to say, till the teeth on the cutting side of the hob appear to travel straight across the face of the blank. In use the blank, of course, must be given the proper speed of rotation to harmonise with the hob. An obvious development of this idea is to slew the hob further round still and cut skew, spiral, or helical gears.

In the Fellows machine, instead of using the rack itself for the purpose of developing the tooth, an intermediary is employed. A cutter, which closely resembles a wheel itself, is made from the rack, and is used to cut the teeth in the blank by a slotting motion. The machine was fully described in THE ENGINEER of August 31st, 1900,

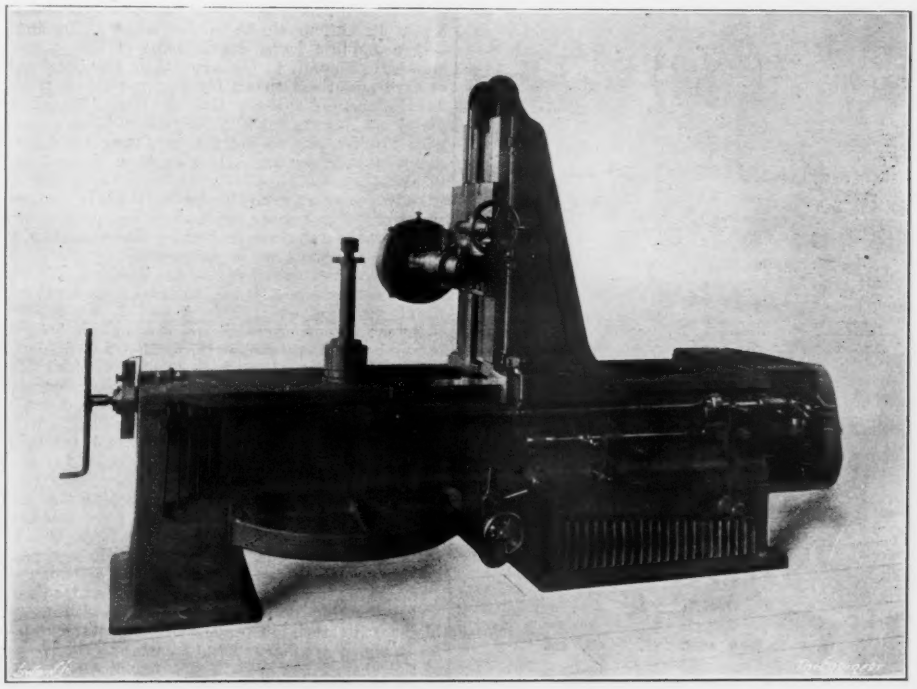


Fig. 2—6-FOOT GEAR-CUTTING MACHINE—CRAVEN BROS., LTD.

where the beautiful method of producing the cutters is also dealt with.

When we come to bevel gear cutters we have, as already mentioned, to meet another set of conditions.

The tooth is taper in two directions, and it is clear, on a moment's consideration, that a milling cutter cannot produce a correct shape at more than one place in each tooth. In certain cases the error may be very small, and by dividing it cunningly may be rendered almost negligible, and when they are short, bevel teeth may be milled, but, at

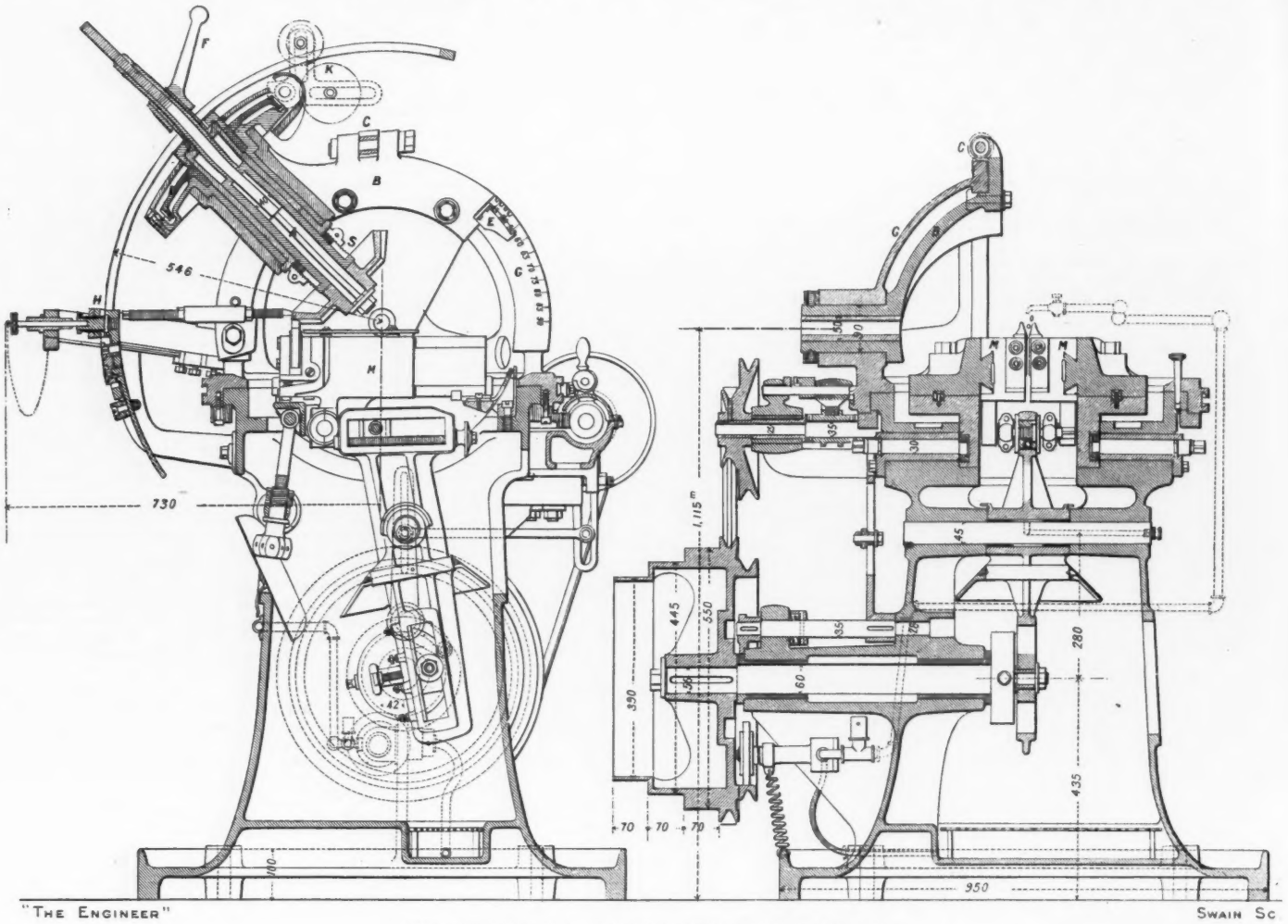


Fig. 3—NARDIN BEVEL GEAR SHAPER—ALFRED HERBERT, LTD.

the best, only an approximately accurate tooth can be produced. Other means have therefore to be sought, and, though a rotary cutter may be employed, as in the Warren machine, a shaping or planing action is in more general use. In some cases, as in the Oerlikon machine described on page xiii., and some forms of the Gleason,

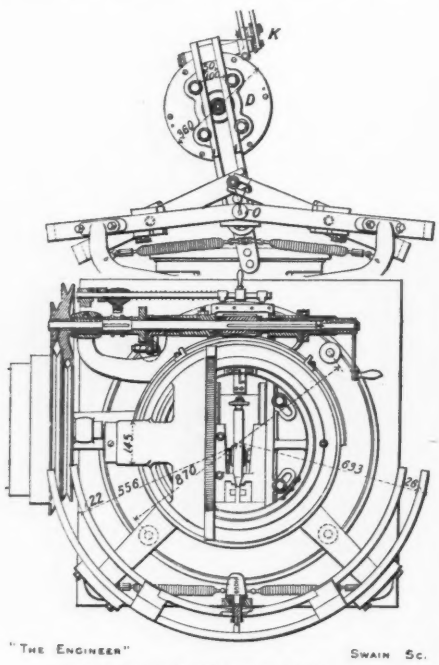


Fig. 4—NARDIN MACHINE, PLAN, &c.

a former is used to guide the tool in the right path, whilst in other machines, such as the Bilgram, the Nardin, and the automatic Gleason—pages ii., xii., and xv.—the principle of the rack already discussed with regard to straight teeth is employed. But in cutting bevel gears it is not sufficient for the blank to revolve as in spur wheel cutting. It must have a rolling motion of the same kind that a cone lying on its side and pushed along a table has, or as the wheel would have if it were pushed freely over the wheel with which it pairs correctly. It is in the means employed to obtain this rolling motion that the most interesting features of these machines are found.

Inventions of gear-cutting machines may be counted by scores, and we do not pretend for a moment that we have in these pages touched upon more than a small number of the many different types there are. We have, however, endeavoured to present descriptions of all the better known kinds, and if any are absent it is more through the makers' fault than ours. Of some machines we have been able to give only very indifferent notices, because the makers would supply no details. We do not think they are wise in that, but that is their affair. On the other hand, several of our own firms, Parkinson, Smith and Coventry, Darling and Sellers, and in a lesser degree, some of the others have allowed us liberally to reproduce their working drawings, or have lent them to us for the purpose of preparing descriptions. To them and to Herr Reinecker and Messieurs Ducommun who have given full drawings, we wish to offer our cordial thanks; their machines will naturally attract more attention than those less fully illustrated.

Before entering upon the description it is necessary to say that the only order followed in the arrangement of the following pages was that which allowed most material to be got into the space at our disposal.

The machine built by Craven Brothers, Limited, of Manchester, presents, it will be seen from the back and front views given in Figs. 1 and 2, no exceptional features; it is an automatic spur gear cutting machine, of sound but ordinary design, the teeth being produced by a shaped milling cutter which has a down feed. It has, as its proportions show, been especially designed for heavy wheels, and will take work up to 6ft. diameter by 12in. face. In one respect the makers have departed from the general custom. It is usual to make the column an integral part of the bed, and move the saddle carrying the blank to or from it to suit the diameter of the work. In this machine the table is fixed, and the standard is moved by a screw indexed to read thousandths of an inch along the bed. It is locked at its correct position before cutting commences. The cutter headstock, which travels up and down this standard, is balanced, and has both hand adjustment and self-acting positive feed motion, with automatic high-speed return independent of the cutter speed. The feeds, which are four in number, can be varied by means of the change box seen in the view of the front of the machine. Change gears at the end of the bed provide six different cutter speeds. The cutter spindle is driven by a quick-threaded worm and gun-metal worm wheel, and is supported in adjustable outer bearings.

The dividing is effected by a worm wheel under the bed of the machine. It is entirely automatic and independent in its speed, and will divide wheels with all numbers from 12 to 100 teeth, except prime numbers—that is, numbers divisible only by themselves or unity—and their multiples. The gears throughout are, of course, machine cut, and are protected by cast iron guards. A tank is provided in the bed for lubricant, which a centrifugal pump raises to the cutter.

The Nardin bevel gear planer is made by the Ateliers de Constructions Mécanique ci-devant Ducommun, of Mulhouse, Alsace; the agents for it in this country are Alfred Herbert, Limited, of Coventry. It is illustrated by Figs. 3 to 6.

We have already explained that a rack with straight-sided teeth may be used to generate correct spur wheels, but in practice a single tool of rack tooth form is used to make one tooth at a time. A bevel wheel with involute teeth has just the same convenient properties that a

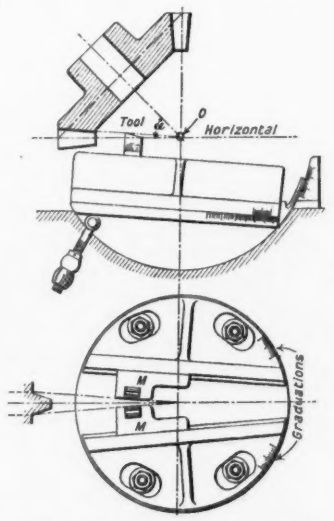


Fig. 5—ADJUSTMENT OF TOOL SLIDES

straight wheel has, but in place of a straight rack we must have a curved one, that is to say, a crown wheel, in order to obtain the proper taper of the teeth. Any bevel wheels that will gear properly with such a crown wheel will run correctly together. This is the basis of the Nardin machine, but just as a single tool takes the place of the rack in the spur wheel machine, so a single tool—duplex, as a matter of fact—takes the place of the crown wheel in this machine. The cutters, therefore, are straight-sided, and are easily produced. Two are used at a time, and they work on opposite sides of a single tooth, not on the adjacent sides of two proximate

teeth, as, for example, a milling cutter does. They cut, too, not with the point only, but with their flats, so that a very smooth tooth is produced. The space described between their two inner and cutting faces is the contour of a true crown wheel tooth with straight sides. It can, therefore, be used for the generation of any bevel wheels, machine is given by special calipers, and the adjustable screw collar S is manipulated till the correct position is obtained. The nut F is then screwed up hard, drawing the boss of the blank firmly against the collar and holding all taut. Additional support is afforded by a thrust or counter screw, which bears against the blank directly in imaginary cone, the point of which lies at the geometrical centre of the machine, whilst the base is out at H, where the rolling mechanism is fixed. This rolling gear is shown best in Fig. 4. Here O is the centre of the machine or the imaginary line—seen end on—about which rolling has to take place. D is as before the

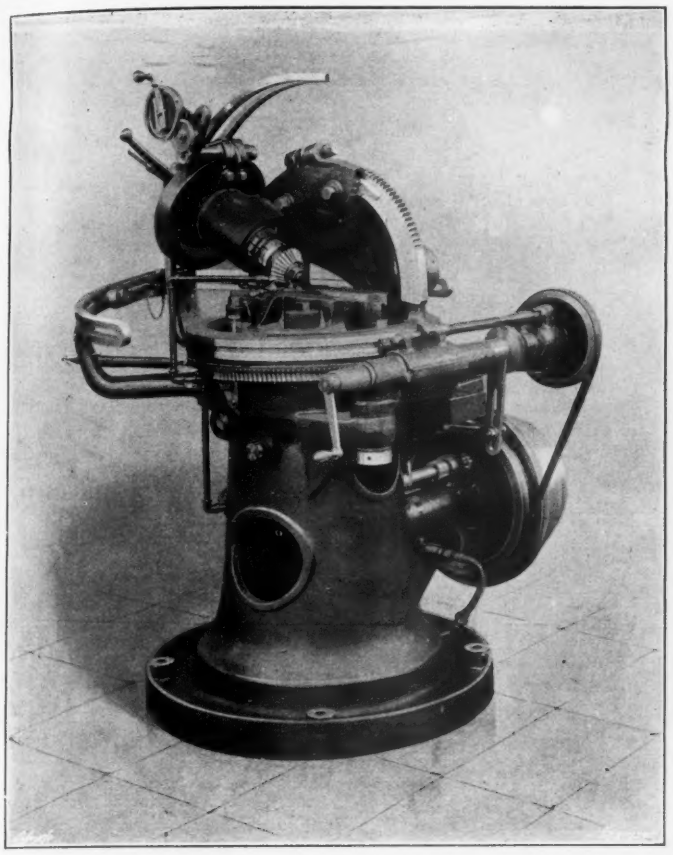


Fig. 6—NARDIN BEVEL GEAR SHAPER

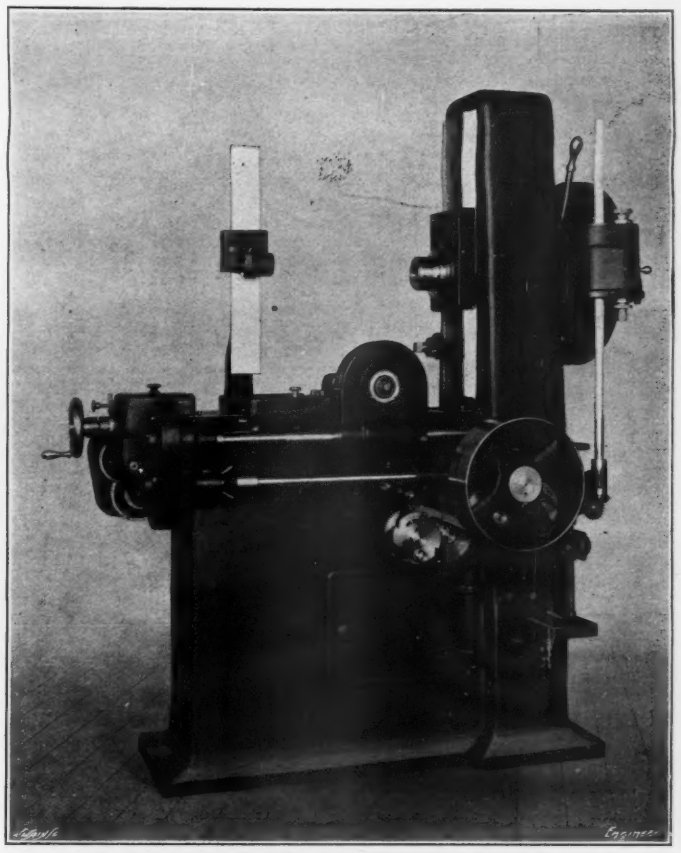


Fig. 7—FLATHER GEAR-CUTTING MACHINE

the necessary adjustment for width of tooth and angle of course being made.

The blank rolls on to the points of the tools, as will be explained later, and hence the teeth can be cut straight from the solid, but it is recommended to rough out the teeth first with a cutter and finish them on a machine of this type.

The machine itself is illustrated by several sectional drawings, Figs. 3 and 4. The blank, it will be seen, is carried on a mandril A, of the form shown clearly in the section. The mandril is carried in a sleeve to which the dividing worm wheel D is keyed, and the whole combination of parts is supported in the sector B, which can be adjusted in a vertical plane by the worm C. A vernier E and a scale permit of its position being accurately gauged. The distance of the back of the tooth from the centre of the front of the tool when large gears are being cut. The sector B is carried on a part G called the "cupola," which is a substantial casting borne on a horizontal turntable, so that it may rotate about the vertical axis of the machine. We can, therefore, by its means obtain the motion that is required, namely, a rolling motion of the tooth to right and left of an imaginary central point in it on the pitch line. In order to obtain this action it is obvious that whilst the centre of the blank is moving there must be little or no horizontal translation of this imaginary point. If we think of a cone lying on a flat surface and rolled a little backwards and forwards, we shall correctly present to our minds the action to be attained; the centre of the cone will move in a horizontal plane, whilst the point on the flat surface will have a very slight movement. The blank forms a part of this dividing worm wheel, and a line from its centre drawn down to meet the line O is the centre line of our imaginary cone. The drawing is not in correct projection. The arm L L is pivoted at O and secured to D, so that if D is shoved bodily to the right it will move about O as centre. It will be seen, furthermore, that since the blank is keyed to D it also will roll round the centre line O, which is, of course, what is wanted. Now D receives this very motion to the right by the rotation of the turntable, so that from it alone the whole motion of the blank is derived, and by this very pretty mechanism the true rolling motion of the tooth is obtained without the intervention of any gears, which need to be fixed in their right ratios, and so on.

This kind of action is difficult to describe, but once it is borne in mind that the whole object is to give a cone—

Fig. 8—ARMSTRONG RACK CUTTER

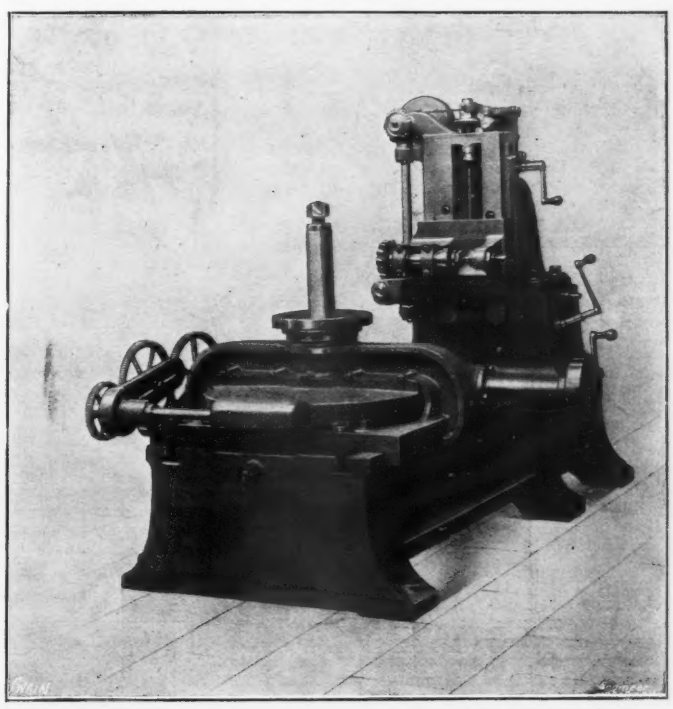


Fig. 9—ARMSTRONG GEAR-CUTTING MACHINE

of which the blank is the only really existing part—a rolling motion about a line on an imaginary plane, the drawings will be understood by a little examination. The purpose of the two helical springs shown is only to resist the motion, and so hold the arm L L steady.

The turntable receives its motion from a worm—seen in the plan view—rotated by a ratchet gear—seen in Fig. 3—which gives a ready means of adjusting the feed. A quick return of the table is obtained from the cord pulleys on the worm shaft. It is necessary to remark that the dividing mechanism is attached to no other part of the machine than the dividing head. The machine is, of course, not fully automatic.

A few words must now be said about the cutting mechanism, but the drawings leave little to explain. The slotted link quick-return motion will be at once recognised in Fig. 3, and the crossheads will be seen in that figure, and in Fig. 5. The slides on which they travel have a double adjustment—best shown in Fig. 5; the first is in a vertical plane to suit the angle at the root of the tooth, the second is in the horizontal plane, to suit the taper of the tooth. The shape of the cutters, and the principle on which they act, have been already discussed.

The machine throughout is provided with scales and verniers for accurate adjustment, and a gauge is provided for getting the correct form of the cutters.

An American machine for which Alfred Herbert, Limited, are also the British agents is the Flather—Fig. 7—in which the family likeness between many American gear cutting machines will be at once recognised. In its main features it differs principally from the Brown and Sharpe machine in the method of guiding the head carrying the work spindle. Instead of the saddle being carried on one side of a standard, it is borne by a stout column brought up right from the base. This column is provided with slides, and has a long rectangular opening through which the work spindle passes to the dividing wheel behind. The design is theoretically sound, since all stresses produced by overhang are obviated. Whether better work is the result of this refinement we are unable to say.

The machine is fully automatic. The dividing mechanism is shown pretty clearly in the engraving. It is locked after each motion. The feed is positive through change gears. The cutter spindle is driven by worm and wheel.

The spur gear hobbing machine illustrated by Fig. 11 is arranged to cut spur gear by the continuous action of a milling cutter made in the form of a hob, as already briefly described, the profile being of rack form; continuous rotation of the wheel blank generates the wheel teeth, and one hob will cut all wheels having the same pitch. It is made by Sir W. G. Armstrong, Whitworth and Co., Limited, of Openshaw. It consists of a bed, the left-hand end being fitted with the work table and dividing arrangement, the right hand forming a slide, which carries the upright and spindle slides. This upright has a longitudinal adjustment to suit the various diameters of wheels and depth of teeth. The drive is by means of a three-speeded cone pulley, on the end of the bed, through bevels R to a shaft in the centre of bed. This shaft rotates a sliding bevel pinion M, gearing with a bevel gear on the vertical shaft in the upright, which drives a sliding bevel pinion, gearing with a bevel wheel W on the short bearing, passing through the centre of rotation of the swivel slide, and thus permitting the slide, and consequently the cutter, to be placed at any angle in relation to the wheel being cut. The bevel wheel last mentioned has keyed to it a mitre, gearing with a corresponding mitre on the transverse shaft in the swivel slide; this shaft at its outer end carries a pinion driving a wheel keyed to the spindle. The spindle runs in conical bear-

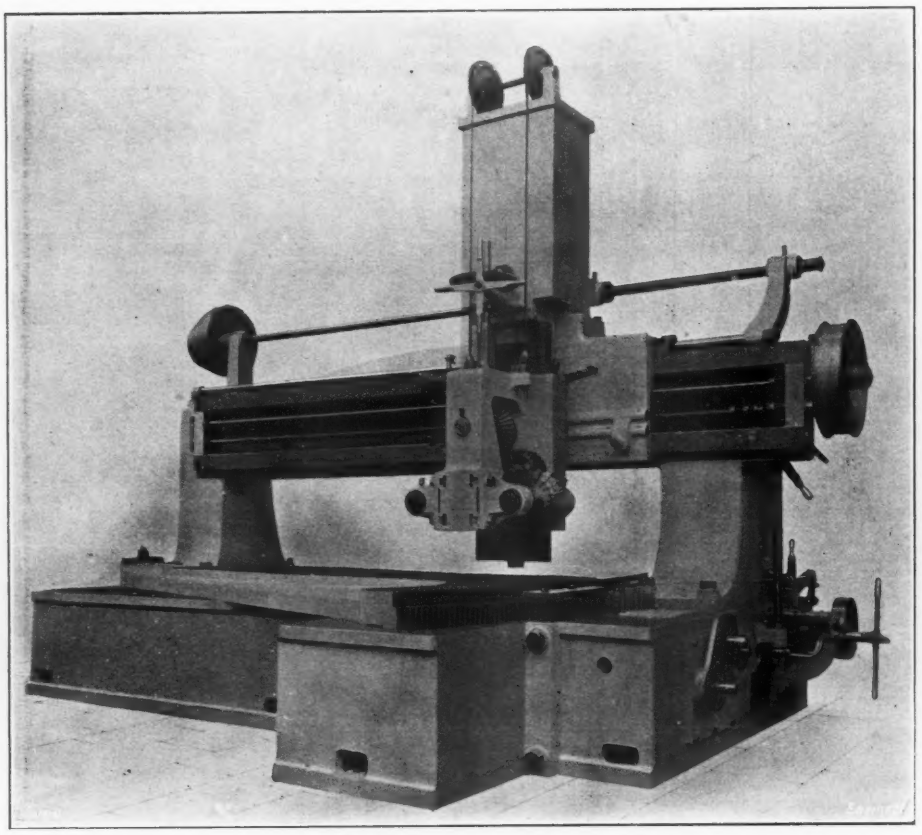


Fig. 10—ARMSTRONG MACHINE FOR CUTTING LARGE SEGMENTS

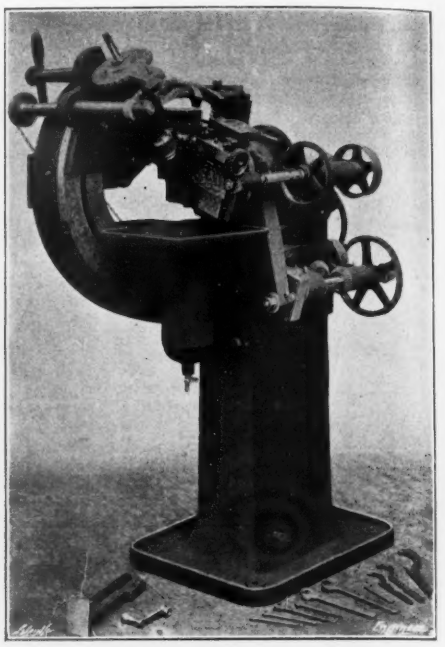


Fig. 12—WARREN BEVEL GEAR SHAPER

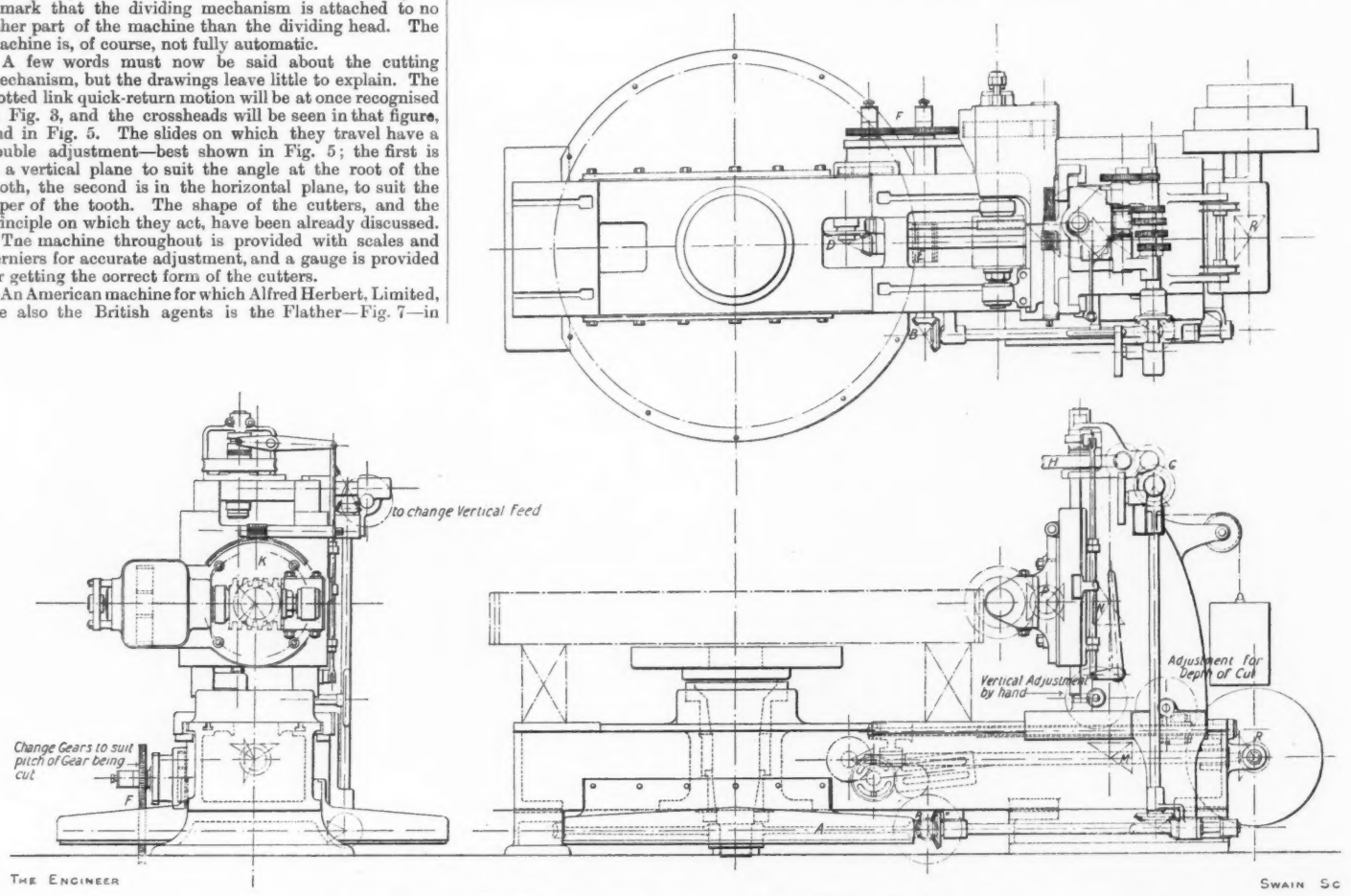


Fig. 11—GEAR HOBBING MACHINE—SIR W. G. ARMSTRONG, WHITWORTH AND CO., LTD.

ings, adjustable for wear, and is cone bored to receive the various mandrils, which are driven by a groove cut across the end of the spindle—see Fig. 15. The driving shaft in the centre of the bed carries at its extreme left-hand end a bevel pinion, driving a bevel wheel D communicating by means of a cross shaft to a change wheel and swing frame arrangement F, thence to the worm gearing with the large worm wheel under the bed, thus setting up a direct connection between the rotation of the cutter and the blank; the ratio of this connection has, of course, to be varied, by means of the change wheels, according to the number of teeth required to be cut. The front end of the worm shaft above referred to gives motion by means of bevel gears to the shaft C, seen at the lower right-hand end of the bed. This shaft carries a sliding bevel pinion gearing to the bevel wheel on the vertical shaft, which in turn gives motion by means of bevels at the top of the upright to a nest of gears G, providing a variation of four different speeds to the worm and worm wheel H, and consequently to the vertical screw in the upright, and thus forms a feed motion for the cutter, which cuts continuously through the blank until the hob, having passed to the bottom position, the wheel is complete, and the feed stops automatically. The spindle slide is balanced, and the hand wheel at the bottom of the upright in front provides a means of raising the cutter to its starting position. The vertical spindle supporting and rotating the work table runs in conical bearings.

An automatic wheel-cutting machine, also by Armstrong, Whitworth, for cutting teeth in either spur or worm wheels from 12in. to 96in. diameter and 14in. face, is shown by Fig. 9. The machine consists of a bed on which a saddle slides, being adjustable by screw to meet the varying diameters of wheels. The saddle carries a dividing worm wheel, centre pin and face plate, to which the wheels to be cut are bolted. Hand or automatic dividing gear is fitted. At the right-hand end of the bed is fitted the upright which carries the cutter slide. The latter can be fixed horizontally when cutting straight spur gear, or set at an angle for worm gear. The cutter spindle is supported at the outer end by a bearing, and is driven by coarse pitch worm gear and belt from a single pulley. The machine is fitted with automatic feed, quick return, and dividing arrangements.

An interesting machine, also constructed by Sir W. G. Armstrong, Whitworth and Co., Limited, of Openshaw, is shown in Fig. 10. It is designed for cutting teeth in the segments of racks for gun turntables, and is capable of taking pieces up to 12ft. radius. It consists of a bed-plate, to which is rigidly secured an arched cross slide, on which slides the cutter head. On the bed-plate is pivoted a planed and grooved table of radial form, to which the work is bolted, having fixed to it the dividing segment. The drive is effected by means of a three-speeded cone pulley at the left-hand end of the cross slide, through a long horizontal shaft, which rotates a sliding bevel pinion on the cutter head slide; this drives, by means of the cross shaft and bevel gears, a vertical cutter head. The lower end of the vertical shaft is provided with a bevel pinion gearing, with bevel wheel, to which is keyed a spur pinion; this in turn rotates the two spindles by means of the spur gears attached thereto, the left-hand spindle being, of course, for external and the right-hand spindle for internal segments. The feed and indexing mechanism is worked from the belt at the back and right-hand end of the cross slide, which drives a pulley at the extreme rear of the bed-plate, and from this all the motions are derived. The pulley rotates a short cross shaft, to which is keyed a mitre, which gears with the mitre on the short cross shaft, previously referred to, through a swing frame and change wheels, a worm, gearing with a worm wheel running loose on its shaft. The short cross shaft continues, and at its extreme end has keyed to it a spur pinion, engaging with a wheel running loose on the shaft. Between the spur wheel and the worm wheel is a sliding friction and a positive clutch. This combination forms a variable down feed and a quick return to the cutter head in the following manner:—The clutch shaft drives by means of the three pairs of mitres the vertical shaft on the outside of the right-hand upright; to the top of this shaft is keyed a mitre, giving motion by means of the mitre and spur wheels to the long shaft in the cross slide, which gives motion to a sliding mitre wheel on the cutter head slide, and thence by means of further mitres to the vertical feed screws. The sliding wheel on the long shaft may be disconnected by means of a hand lever on the slide, thus permitting the adjustment of the cutter slide by hand, by means of the cross handles in front; the cutter slide mitre; this engages with two mitres, one on each side, one of which drives the indexing or dividing motion by means of the short shaft and bevel wheels. The indexing box is arranged to revolve always four turns to complete the dividing. This four-turn movement passes through the cross shaft, thence through two pairs of mitres to the swing frame and change-wheel arrangement, and so to the worm and worm wheel on the vertical shaft. This shaft carries at the top a spur pinion, which engages with the dividing segment on the pivoting table, and is driven by the second being balanced renders this adjustment easy. The saddle carries at its left side a vertical rod to which may be fixed, in any desired position, split stops. A bracket on the cutter slide strikes one of these stops at each end of the downward or upward stroke, so giving movement by means of a sliding lever to a long shaft on the top of the cross slide; this shaft, at its extreme right hand, carries a lever which operates a vertical rod actuating at its lower end the reversing and trip movement for indexing previously referred to. Safety mechanism is provided,

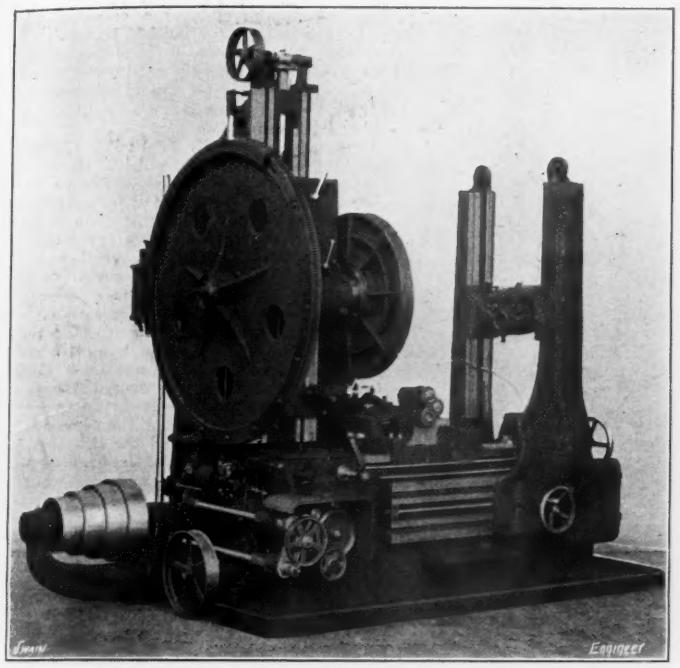


Fig. 13—GEAR-CUTTING MACHINE—LUDW. LOEWE

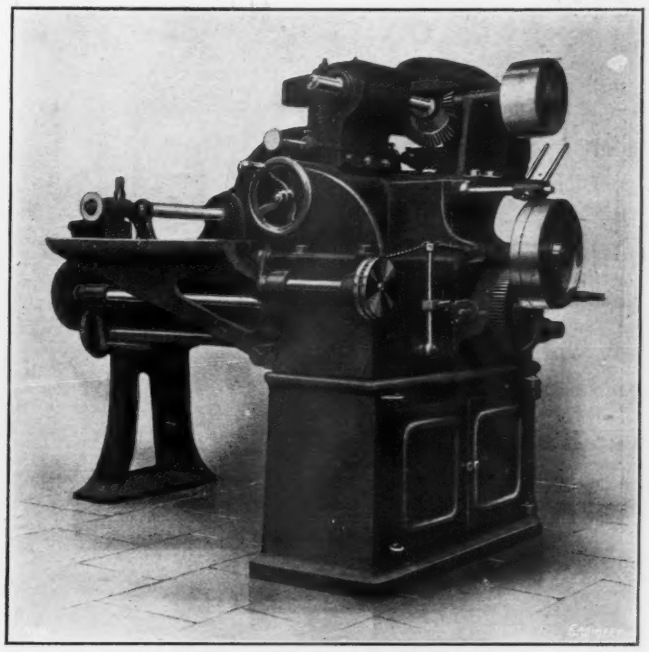


Fig. 14 HORIZONTAL GEAR-CUTTING MACHINE—G. F. SMITH, LTD.

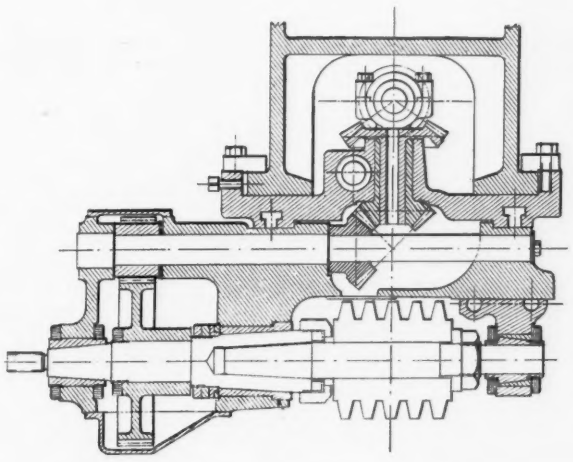


Fig. 15—ARMSTRONG SPINDLE DRIVE

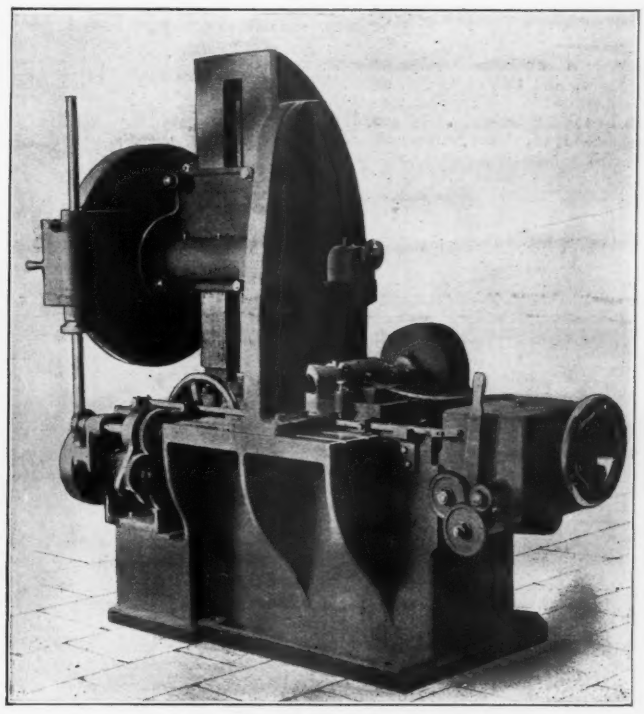


Fig. 16—VERTICAL GEAR-CUTTING MACHINE—G. F. SMITH, LTD.

rendering false indexing impossible. The cutter slide remains at the top of the slide until the indexing is complete, and should anything prevent this, the cutter head remains inoperative at the top. The large pulley at the right-hand end of the cross slide operates by means of spur wheels and clutch-reversing mitres, the quick run is carried in a spindle on a bracket which can be inclined to the required angle. Dividing gear is mounted on the spindle. Segments to suit the different gears that may be cut are provided with the machine; one dividing plate for each wheel that can be cut is also provided. The advantages claimed by the makers for this

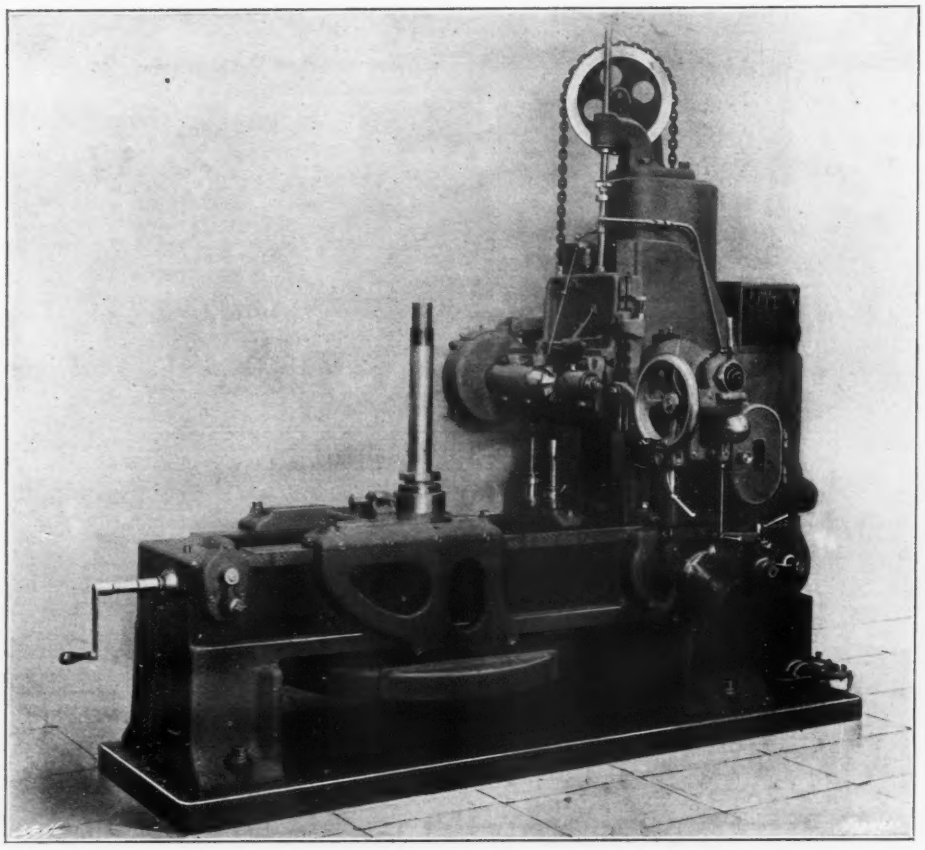


Fig. 17—4-FOOT GEAR-CUTTING MACHINE—DARLING AND SELLERS, LTD.

for moving the cutter-head saddle along the cross slide, the final adjustment being operated by hand by means of a handle conveniently placed on the saddle itself.

We show also—Fig. 8—a small rack-cutting machine, made also by Sir W. G. Armstrong, Whitworth and Co. It hardly calls for description, as the illustration is practically self-explanatory. The machine will take six racks side by side up to 1¼in. wide by 3½in. deep, and cuts up to ¾in. pitch.

The Warren automatic bevel gear cutter is made by Ludw. Loewe and Co., of Berlin, and differs from any others illustrated in this Supplement in that it develops a tooth by milling instead of by shaping. We give an illustration of it, reproduced from a photograph, in Fig. 12, but as it has been impossible to obtain drawings of a machine, we shall not be able to give a very complete account of its action. The particulars, too, which the

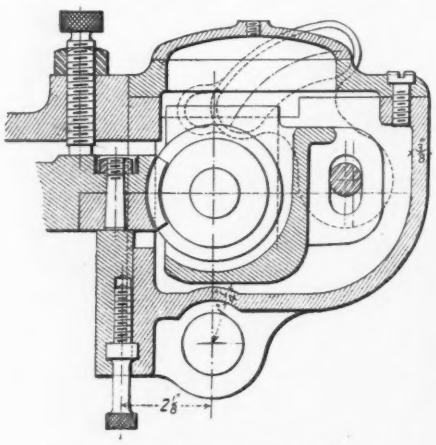


Fig. 18—DIVIDING WORM BOX

makers have supplied us are of the scantiest. Certain broad facts may be given. The cutters are two small mills facing each other, and cutting on their inner faces, which are inclined so that the space between them resembles a rack form of tooth. The slides in which the two cutter heads are mounted can be inclined to each other at the proper angle for the taper of the bevel tooth. The cutter heads travel down their slides to effect the feed, and at the same time the head carrying the slides is swung in a vertical plane about the geometrical centre line of the machine. On the top of this head a portion of a crown wheel is mounted and gears with a quadrant of suitable dimensions keyed to the work spindle. It will be seen, then, that as the head swings backwards and forwards, the spindle, and with it the blank, are caused to rotate, and the rolling action is produced. The blank

type of machine are that it does away with expensive formers; that a complete tooth is milled at one cut, and the output of the machine is from two to three times that of the bevel gear planer; and finally, that a great variety of pitches can be cut with a small number of cutters of simple form and inexpensive. The machine shown, it should be remarked, is only intended for quite small work, 8in. being the largest wheel that can be milled.

Three sizes of gear cutters are also made by Ludw. Loewe. They are entirely automatic. The smallest cuts gears up to 19⅝in. diameter by 11in. wide. The second gears up to 48in. by 11in. face; the largest, which we illustrate, Fig. 13, up to 78⅝in. by 13in. face. By the use of roughing cutters gear can be cut on the second up to 1¾in., and on the last up to 1¼in. diametrical pitch. The machines are of the ordinary horizontal type, but the designs have been worked out with much care, and the finish is excellent. The machine illustrated has a dividing wheel 57⅛in. diameter, made in two parts to secure accuracy. The feeds vary between ·01in. and ·142in. per revolution of the cutter, and eight changes are obtainable. This firm makes also an ingenious gear cutting device which can be mounted on the table of a universal milling machine. It is fully automatic cutting, returning, dividing, just as in a large machine. It is not, of course, claimed for it that the accuracy is equal to that of regular gear cutting machines, but for much small work not requiring the highest accuracy it is a convenient addition to the milling machine.

Two machines made by G. F. Smith, Limited, of Halifax, are illustrated in Figs. 14 and 16. The first is of the horizontal type, and will take wheels up to 4ft. diameter by 12in. face. The feed and dividing gear are automatic. The spindle is driven by a worm running in an oil bath, and positive feed gear is provided. The worm of this machine is divided longitudinally to take up wear; it can be thrown right out of gear when desired.

The second machine is of the vertical pattern, and takes wheels up to 52in. diameter. The carriage has a traverse of 12in. The cutter spindle is driven by a worm and wheel running in oil; the saddle is guided on one shear only. The spindle has long adjustable bearings. The various changes of speed are secured through a set of change wheels. The feed also is driven by a worm, with spiral gear for the quick return. The vertical adjustment may be made to $\frac{1}{1000}$in., and the elevating screw has a ball thrust. Other facts about the machine will be obvious from the engraving.

Among the comparatively few English gear-cutting machines, one of the most complete is that made by Darling and Sellers, Limited, of Keighley, and we are glad to be able to illustrate two different sizes of it in this Supplement. The machines shown are both fairly large, one taking wheels up to 4ft. and the other up to 6ft. in diameter. Certain general features at once strike the eye—the teeth are milled, not developed; the work is carried on a vertical spindle; the standard, or upright, is bolted to the bed, and the saddle is moved relatively to it, according to the diameter of the wheel being cut. Such broad facts also as that the cutter head is balanced and that the shears are square edged will also be observed, whilst the carefully designed guards for the wheels and the tray in which the whole machine stands will not escape attention. One final prominent feature will also be noticed. It is the design of the saddle and the method of supporting it from the face of the bed by outside brackets. It will not escape attention that there is no circular table, as in many machines of this type. Of the method of supporting the blank close to the cutter we shall speak presently.

Let us now consider, first, the smaller machine in

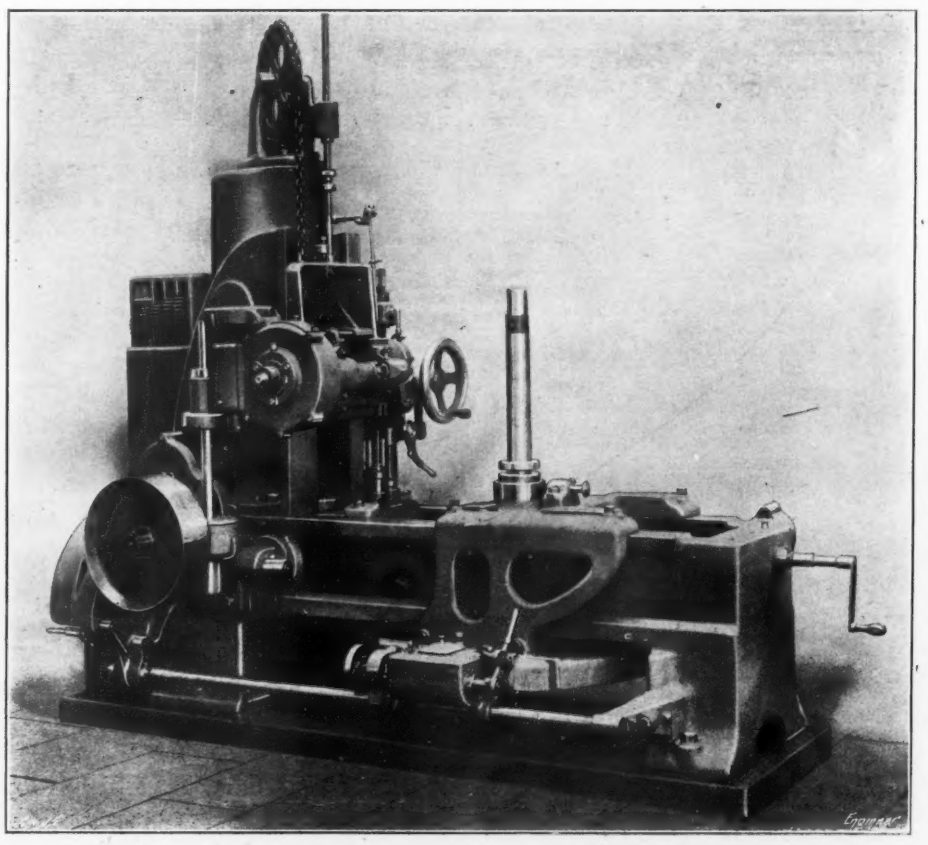


Fig. 19—4-FOOT GEAR-CUTTING MACHINE—DARLING AND SELLERS, LTD.

greater detail; the larger machine closely resembles it, but is provided with a special device for clamping the work, which must be dealt with separately. The drive is taken on a single belt pulley, 20in. diameter by 5½in. wide, from a countershaft, running at 240 revolutions per minute. It drives a worm on a vertical shaft, seen in

the engraving—Fig. 19—and marked A in the drawing—Fig. 22. On this shaft a pinion D is mounted, which drives a shaft B, to the right and behind it. B in its turn drives C by change wheels, one of which is mounted on the extension of the shaft of the spiral pinion E, which drives the cutter spindle. The spindle itself is hollow, so that it may take any arbor, and is carried in a long taper bearing, which it is carefully ground to fit. The outer end of the arbor is carried in an outboard bearing, which can be readily removed to change cutters, and the endwise adjustment is effected by moving the main spindle bearing bodily to left or right. A useful feature in this connection is the permanent gauge or pointer, hinged to the vertical slide. It can be turned down instantly to test the centrality of the cutter.

The slide is guided on the vertical face of the standard in the same manner as the saddles on the makers' lathes—that is, on what is called for convenience the "narrow guiding principle." The down feed of the cutter slide is effected by gearing on the side of the machine, shown in Fig. 17. Power is brought to the change gear-box from the driving side of the machine through the standard. The wheels provided which give nine rates of feed, are contained in a rack, handily placed above the gear-box. The maximum range of feed in this machine is 16in. By throwing the automatic gear out of action, the hand wheel shown can be used to raise or lower the slide. The other parts seen are the automatic gear for knocking out and releasing the down feed at the proper moment, and for re-engaging it when the cut is to re-commence. The adjustable strikers are clearly shown. The cutter head, on being released, rises free and quickly, being brought up without shock by an air buffer.

Power from the change feed box is taken up to a bronze worm wheel inside the spherical box seen on the side of the standard in Fig. 17. This worm wheel is loose on a horizontal spindle, which carries a pinion gearing with a spiral rack on the back of the cutter slide. As this pinion rotates the slide is fed downwards. There are two methods of revolving it, either by the hand wheel shown, or by power. Two separate clutches are provided for this purpose, and a safety catch is fitted which prevents any chance of both being in at once. The main or power clutch is spring loaded, so that it always tends to keep in, but the lever which actuates its sliding part is moved by strikers on the cutter slide, and by freeing the clutch releases the rack pinion and allows the slide to ascend rapidly, until it is brought up quietly by the buffer in the bracket at the head of the machine. At the same moment a catch holding up the vertical rod on which the weight seen just below the worm box rests is released, the rod falls, and the indexing mechanism starts. The plate seen under the rod in question makes a single revolution, and then the projection on it raises the rod has come to the right point, so that it is impossible to commence cutting at a wrong place.

The indexing mechanism is driven partly through the gear box—Fig. 21—and partly through change gearing on the other side—Fig. 19. Gears of this kind are frequently provided with a friction drive, and this will be seen in the connections of the two wheels to the right in Fig. 21. The wheel marked 72 T, which is driven from a pinion above, is loose, save for frictional contact with a disc behind it, and the 48 T wheel in front of it, between which it is clamped by the two lock nuts on its spindle. Thus both the 48 T and 24 T are driven by it, and they drive respectively a 48 T and a 72, either of which may be clutched to a spindle carrying an 18 T pinion. This pinion, through an idler of 48 T, drives a wheel of 72 T on the indexing shaft. This shaft is led back across the machine to the change gear, whence a shaft runs to the worm. The worm wheel is keyed to the lower end of a hollow vertical shaft in the saddle 4¾in. in diameter, parallel, and 15⅝in. long carefully fitted to its bearings for the whole length. The hole in this shaft is taper at the top to accommodate the mandrils which pass right through it, and are held in by a nut at the bottom end.

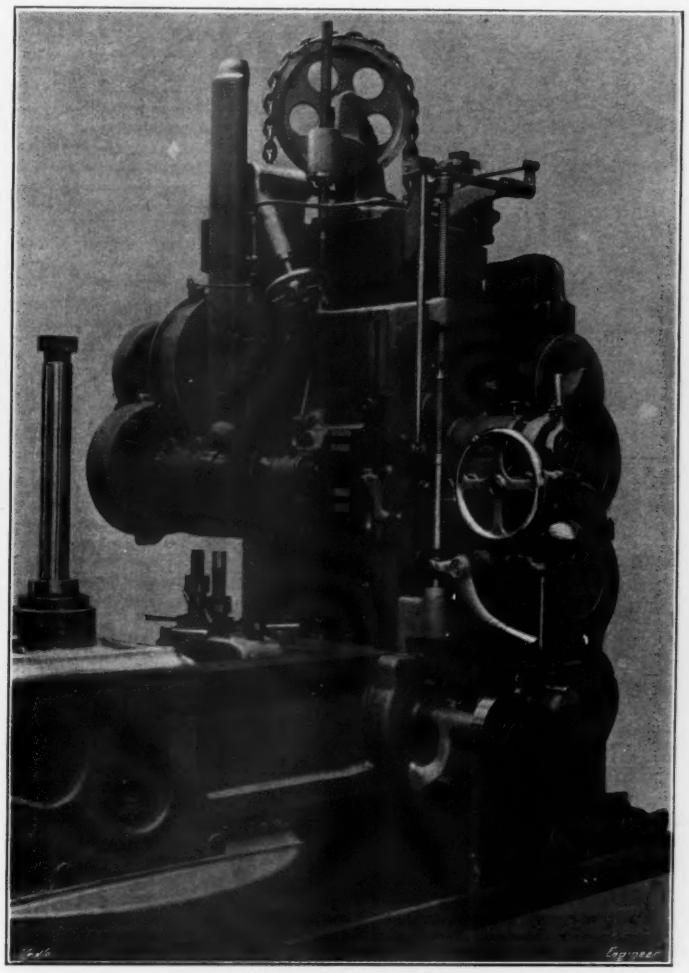


Fig. 20—6-FOOT GEAR-CUTTING MACHINE—DARLING AND SELLERS

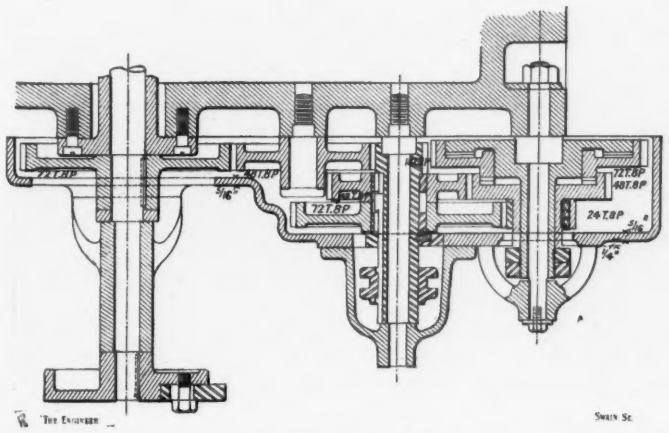


Fig. 21—INDEX GEAR BOX

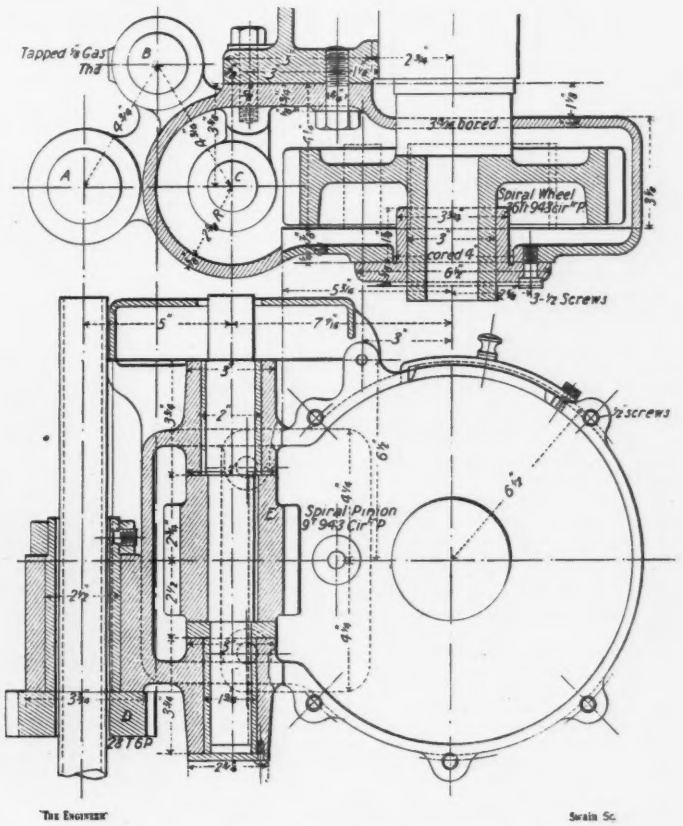


Fig. 22—SPIRAL DRIVE

The dividing wheel and its mechanism are seen best in Fig. 19. The worm wheel is 2ft. 11in. diameter, and has 240 teeth of ⅜in. pitch, double thread. It and the worm are entirely enclosed, so that neither chips from the machine nor dust can find entrance to them. A small drawing, Fig. 18, of the worm shows how it can be entirely withdrawn to leave the wheel free when making adjustments and so on. A small portion of the section of the worm wheel in the same drawing shows its construction. It consists of two parts, divided circumferentially, and carefully pinned together. This is an old, but a very excellent, method of producing a true worm wheel. The two parts are fastened together and hobbed. The ring is then moved round a portion of a turn. Any irregularities in the pitch are at once shown up and are hobbed off. The same operation is repeated again until no measurable inaccuracies remain. The worm is driven by a lay shaft, on which change wheels to give the desired spacing are keyed. Forty-two wheels are provided for this purpose, and they give all division up to 100 and all except prime numbers between 100 and 240.

The saddle is moved along the bed by a screw and handle, fitted with micrometer scale, reading to thousandths of an inch. The work is supported close to the cutter by two adjustable screw rests, mounted on a slide, which can be locked to the bed.

Turning to the larger machine, Fig. 20, of which a general drawing and engraving of the standard are given, it will be seen that the resemblance to the smaller machine is very close. Its range is, of course, greater, as it will take from 3in. diameter up to 72in. diameter by 16in. face, and will cut circular pitches up to 2½in. In this machine the feed and the spindle are driven by separate pulleys, the belt for the former being brought right on to the cutter slide itself. The feed pulley is on the front of the machine.

The additional mechanism operates the clamping ram, which is seen on the cutter slide just above the rim steadies. This ram has a long screw attached to it, by which it is raised or lowered by a phosphor bronze revolving nut. This nut can be driven by hand when required, but when in use its action is automatic, a friction drive pressing it down on to the work, and a positive clutch raising it again when the blank is to be rotated. The back pulley shaft supplies the power for this operation, whilst the clutches are worked from the cutter slide by the tappets and rods shown in the illustrations. By this ingenious arrangement the work is held in a vice quite close to the cutters, and is thus steadied excellently for the heaviest cuts.

Several machines of the hobbing type are made by John Holroyd and Co., Limited, of Milnrow. One of them is illustrated by Fig. 23. The machine, it will be seen, consists of a bed, carrying a horizontal face plate, on which the blank is chucked. No adjustment of the blank is required other than to see that it fits the mandril accurately and revolves quite truly. The chuck has a vertical central spindle which descends between the shears, and it is further supported by an outside ring bearing. It is revolved by a worm, and in order to take up all wear the worm is made in two separate portions which can be adjusted along the worm once more. The blank has then been rotated the required amount, and the clutch is put in automatically again, and another feed commenced. A secondary catch prevents the movement of the clutch until the indexing mechanism spindle. The hob or cutter is carried on a counterbalanced saddle on a standard at the end of the machine. The cutter head is bolted to this saddle, but can be inclined to any necessary position, a scale divided in

degrees being marked round its edge for this purpose The spindle is driven by internal gear coupled through two sets of bevel gear to the driving shaft. The saddle is led downwards by a screw which is operated from the opposite side of the machine to that shown. It is driven from the feed shaft by a pitch chain at the end of the

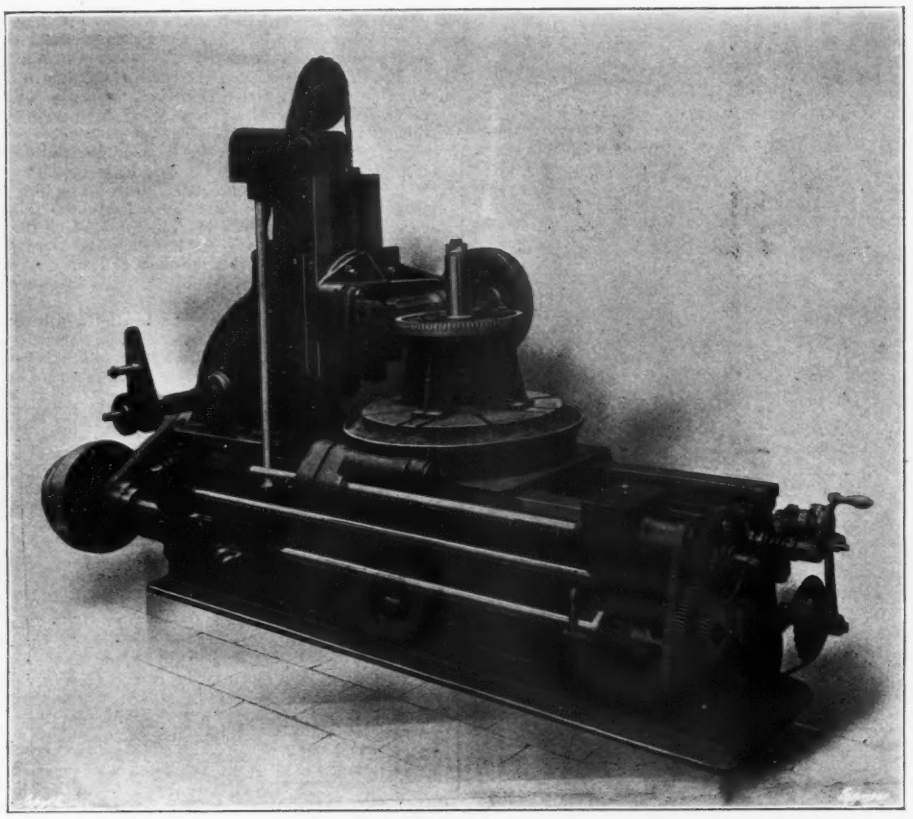


Fig. 23—GEAR HOBBING MACHINE—JOHN HOLROYD AND CO.

machine driving a lay shaft at the back, which operates a ratchet wheel, and so drives through worm and worm wheel the feed screw. The feed is adjustable, but is, of course, independent, whilst the speed of rotation of the hob and the blank must harmonise. Their relative speeds are obtained by a set of change wheels at the end of the bed, and since both are positively driven, there is no danger of a defect in the pitch occurring. In hobbing gear in this machine the full depth is made in one cut down, but the blank makes many complete revolutions before the full width of the teeth is cut. A wheel partly cut is seen in the engraving.

We have, so far, considered the machine as used only for hobbing straight gears, but it can be used also for cutting gears with a milling cutter in the usual way, for producing worm wheels, or for cutting spiral wheels with a hob. When used as a milling machine dividing has to be effected by hand, the blank being locked whilst each tooth is cut. In this case a handle is mounted on the lay shaft, which drives the dividing worm. The necessary gear wheels are fitted on the swing frame, as before, but a plunger engages with a disc on the feed shaft, which acts as the dividing plate.

When the machine is employed to cut worm wheels the hob is fixed horizontally in the saddle, which is brought down to the proper level and locked, the vertical feeds being, of course, cut out. The right wheels are put on to give the correct speed of rotation to the blank, and the feed screw on the table is put into action. This screw is driven by worm gearing through a clutch. Beside it in the bed there lies another screw of smaller diameter provided with a nut and a micrometer scale, by means of which the exact depth of the tooth can be adjusted. The table, by coming into contact with the nut, pulls the clutch out of gear and stops the feed.

Finally, we have to consider the arrangements for cutting spiral gear. In this case the relative speed of the cutter and the blank must be very accurately adjusted to obtain the desired angle of the tooth. The middle lay shaft of the three, seen in the front of the machine, is now employed, and it drives the worm through a differential gear in the box near the end of the bed. It, itself, is driven by gear wheels placed on the swing frame mounted on a bracket projecting from the upright.

From this brief description a general idea of the various work that the machine can perform will be gathered.

As an example of an automatic spur gear cutting machine of large size, we reproduce a photograph—Fig. 24—of a tool made by John Hetherington and Sons, Limited, of Manchester, which will take work up to 8ft. diameter by 16in. deep and 3in. pitch. We need not point out that it is a machine of the milling type. The cutter is mounted upon a hard steel mandril provided with an adjustable outer end conical bearing, and fitted with nuts on a square thread for clamping it. It has a variable self-acting feed and an automatic quick return motion. The feed takes place through change wheels, a worm, and gun-metal worm wheel, and the big square-threaded screw seen in the illustration. Division or indexing may be effected either automatically or by hand, the train of gear for the purpose being thus comprehensively described in the specification:—"Automatically from main drive through spur gear, worm, worm wheel—enclosed in oil trough—crank disc, four-tooth ratchet wheel—always making one revolution—mitre wheels, cut change wheels, cut steel worm revolving in oil trough, split worm wheel with adjusting and lock screws for taking up all wear, cast iron spindle tube revolving in double conical bearing, with lock nuts and friction washer, top end screwed and fitted with a removable circular table having slots cast in, and provided with hard steel wheel blank mandril coned to fit the cast iron spindle tube, with lock nuts and washers."

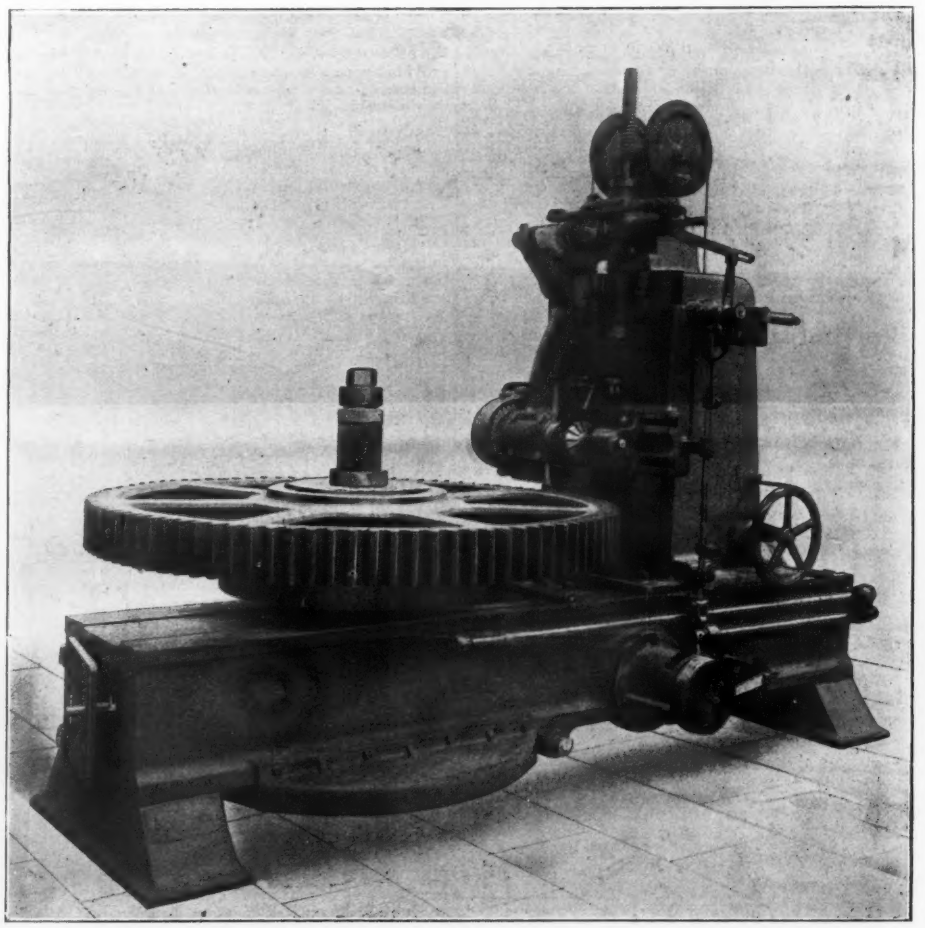


Fig. 24—8-FOOT GEAR-CUTTING MACHINE—JOHN HETHERINGTON AND SONS, LTD.

The drive is taken from a three-step cone pulley, designed for a high velocity belt, through mitre wheels on to a worm driving a gun-metal wheel, and so by cut steel wheels to the cutter mandril. The dividing wheel of this machine is 48in. diameter; the feeds vary between ¾in. and 4¾in. per minute, and cutters up to 9¼in. diameter can be used. The machine complete weighs something like six tons, from which an idea of its size may be gained.

A great variety of patterns and sizes of machines for cutting all kinds of gears are made by Herr J. E. Reinecker of Chemnitz-Gablenz, for whom the agents in this country are Messrs. Pfeil and Co., of St. John-street, Clerkenwell. Several of these machines we illustrate by reproductions of photographs, and of one of them, the universal gear-cutter, we give also a number of drawings.

Let us deal first with the bevel gear-shapers illustrated in Figs. 37 and 38. They are of the well-known Bilgram type. The first is semi-automatic, requiring the whole attention of the operator; the second is fully automatic. The machines will take respectively wheels from 2in. up to 14¼in., and 2in. up to 16in., with face widths of 6in. Either machine will cut teeth of 1¾in. circular pitch from the solid. Several other sizes, larger and smaller, are made.

Although the action of the Bilgram machine is very generally known, since it is one of the oldest of the bevel gear generators, a few words of description will not be out of place here. We shall refer to the semi-automatic machine, as we hope to be able to go fairly fully into the full automatic on another occasion. The Bilgram machine generates the work in much the same way as the Ducommun machine—described on page ii.—does, but there are several essential differences. A single tool is used, and it has straight sides like the teeth of a rack, but it is narrower than a tooth space. It is fixed in a swing tool-box, and has a quick return reciprocating action. Means for adjusting it to the right depth and so on are provided, but it and its connections are otherwise quite simple. The shaping work is done wholly by the motion of the blank. It is mounted on an arbor in the usual way. The arbor is placed between two quadrants, and it can be inclined to any angle, a vernier on one of the quadrants providing the means for setting it accurately. Suitable dividing gear is attached to and operated by hand after the completion of each tooth space. The quadrants or cheeks carrying the spindle stand upright on a turntable, which revolves in a horizontal plane. All that the feed motion does is to turn this table slowly round through a short distance on either side of a centre line. The rolling motion is obtained in an exceedingly simple and ingenious manner. On to the spindle may be fastened various castings called roll cones; they are simply quadrants of diameters corresponding to the angles of the gears that may be cut. In this machine they range from 11¼ deg. up to 75 deg., and a complete set, which includes twenty-two of them, covers all likely gears. To opposite ends of this roll cone steel tapes in large, and steel wires in smaller machines are fastened. The tapes lap half-way round the cone in opposite directions, are drawn tight, and fastened to the framework of the machine. It will be

seen that any movement sideways of the spindle, such as it receives from the feed, will cause one of the tapes to pull the spindle round. In this manner the correct rolling action is obtained, the blank being given just such a motion as it would have did it roll upon its pitch plane. A tooth can be cut straight from the solid, but it is usual to block out the teeth first and then shape them off right and left with other tools. The finishing tool, it will be observed, cuts with its flank, and the result is a very smooth tooth.

The machine shown in Fig. 28 hobs gear wheels in the same manner as several other machines illustrated in this Supplement, but is arranged differently. The method of operating the machine is just the same as the others. The wheel blank is keyed on an arbor which is rotated by a worm wheel and gearing at the correct speed. The cutter also is driven at an appropriate speed, the fact to notice being that internal gear is used to drive it. The hob can, of course, be swung round to angles to suit its pitch. A special machine for milling spiral gear is also made by Herr Reinecker. The blank is caused to rotate at a speed dependent on the pitch of the gears, and the milling cutter is also fed across it at a corresponding speed. The result of this combined rotation of the wheel and traverse of the cutter is, of course, the production of a sloping tooth, the relative speed of the two determining the angle. It is needless to add that the cutter must, of course, be set to the same angle. Machines of this type will cut up to 36in. diameter.

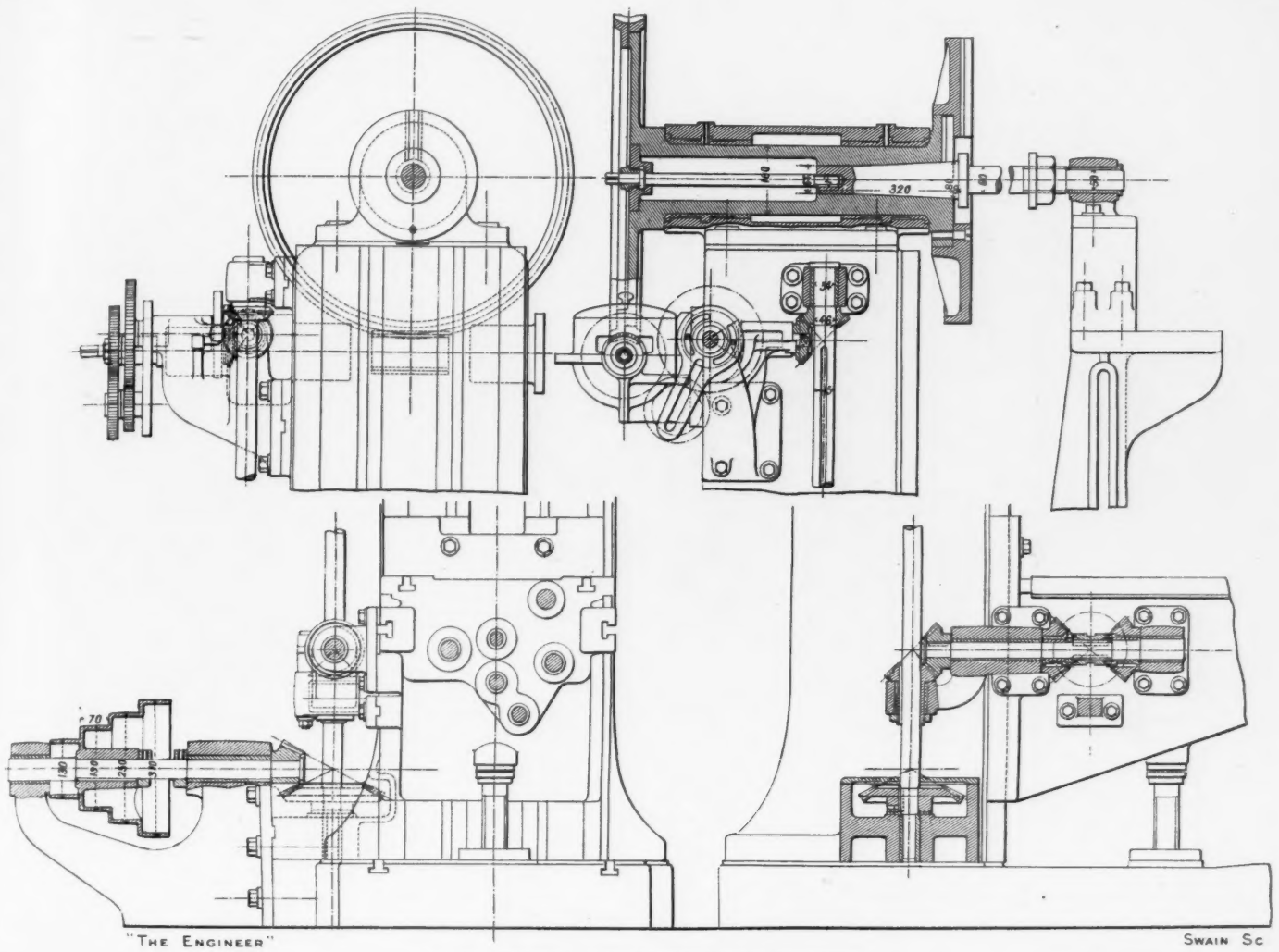


Fig. 25—UNIVERSAL GEAR-CUTTING MACHINE—REINECKER

Several sizes of universal gear cutters are made by this firm; one of the smaller sizes, known as No. 2, we illustrate, Fig. 29. A larger machine, known as No. 4, takes wheels up to 80in. pitch diameter by 10in. wide.

Into the construction of the No. 2 universal machine we shall go pretty fully with the help of the drawings. This machine is adapted for cutting worm, spur, and spiral gear up to 40in. diameter by 10in. wide. On the far side of the column is a four-step cone for the drive; it is better shown in the drawing, Fig. 25. It transmits through a pair of bevel wheels to a vertical shaft at the side of the column; from this shaft another is taken by mitre gears to a reversing gear—see Fig. 26—on the knee bracket, whilst at the top of the shaft another mitre gear drives a set of change wheels for the dividing worm wheel. The worm can be driven from either side of the machine, as shown in Fig. 31, and for a reason to be explained later. The gear we are at present discussing drives the differential wheel A; the wheel B is keyed to the hollow worm shaft, whilst the pinions C are on a cross-piece keyed to the shaft D, on which another worm wheel is fastened. This shaft is also driven by a set of change wheels, *a*, *b*, *c*, *d*, driven by the six-step feed cone shown. This cone is on a shaft *e*, Fig. 27, which shows the whole connection very completely. It will be at once obvious that by employing different sets of change gears on the two sides of the machine, the two members A and C of the differential will be run at different speeds, and hence any desired speed of rotation may be given to the worm. This is absolutely essential when hobbing spiral gears, and all machines for this purpose are provided with differentials of some kind. The gearing of the saddle is shown by Figs. 26 and 30, and requires little explanation beyond saying that the arrangement differs a little from that of the engraving, Fig. 29. The method of driving the cutter spindle by a central bevel wheel and internal gear is well shown in Fig. 30. The longitudinal feed which is employed when hobbing worm wheels with a taper hob is also

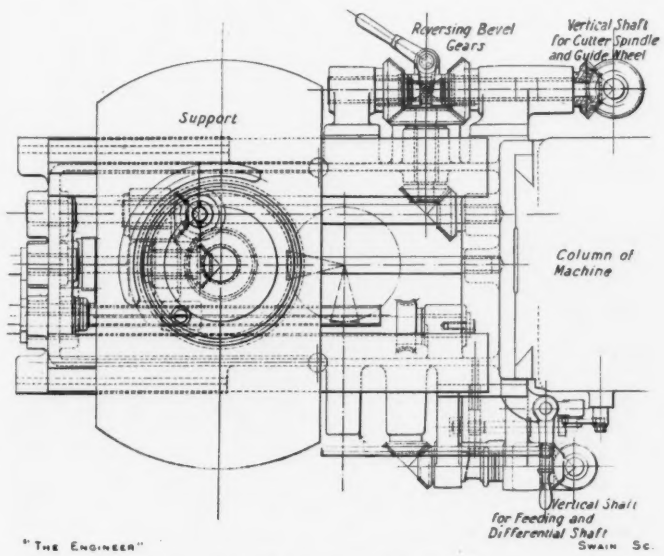


Fig. 26—PLAN OF UNIVERSAL MACHINE

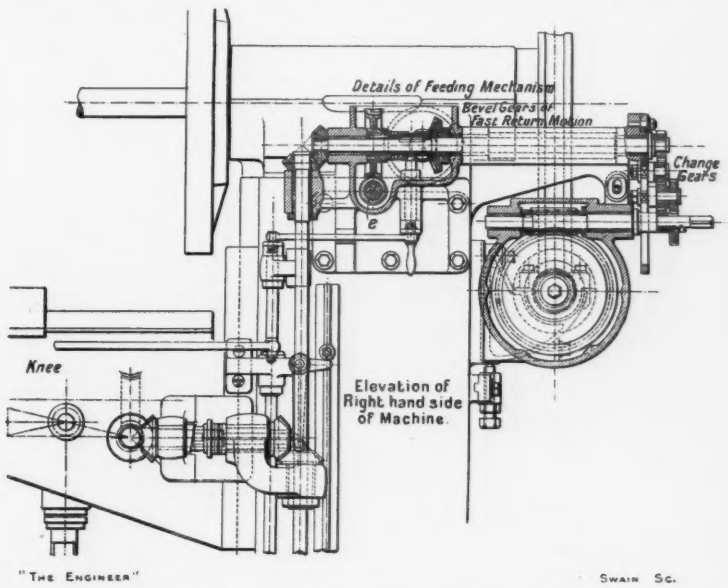


Fig. 27—FEED MECHANISM

shown in this section. The plan view in Fig. 31 shows the dividing mechanism. When it is in use the dividing plate A is freed from the bevel C by loosening and withdrawing the locking bolt B. A handle is put on D, and the change gear causes A to make one complete revolution per division.

Looking at the construction of this machine, one cannot but be struck by the number of bevel gears employed, and the confidence of the maker in the excellence of the gears he produces by his own methods is obviously profound. That the wheels are excellently made and truly paired is evident from the fact that a machine of this kind with many gears in operation may be pulled round by hand without much effort.

We have touched upon the uses of the various parts in the course of the description, but a few words more may be said on this subject. The machine is actually universal. It will cut teeth in the ordinary way by milling, division taking place by hand; or it will hob gear, division taking place automatically and continuously. Worm wheels may be produced either by the ordinary method, with a parallel hob, or by the Reinecker method, with a taper hob, Fig. 32, which, as everybody knows, now-a-days, advances tangentially across the wheel instead of diametrically, and the feed is produced by its taper form. It is claimed for it that it produces a wheel of a very high order of accuracy. Spiral or skew gear may also be cut on this machine with a single cutter, dividing by hand, or with a hob. Up to angles of about 30 deg. such spirals can be cut with the ordinary spindle head, but for greater angles the special spindle head shown in the engraving—Fig. 29—is mounted on the knee bracket. This arrangement, besides permitting of the milling of skew wheels up to the largest angles, has an excentric drop motion by which the cutter is lowered out of contact with the blank during its return motion.

The following data as to speeds and feeds may be found useful:—The cutter spindle speeds are 24, 38, 60, and 102 per minute; the feeds are twelve in number, in two series, ·12, ·19, ·25, ·44, ·64, 1·08in.; and 1·24, 2·04, 3·12, 4·64, 7·04, and 11·4in. These rates of feed may be increased by four by change wheels at the front of the knee. There are also twelve changes of vertical feed.

It may be added, in conclusion, that automatic stop gears are provided for all the motions for which they are required.

The gear hobbing machine, Fig. 36, made by Schuchardt and Schutte, of Berlin, and 34, Victoria-street, does not differ at all in principle and little in form from others illustrated in these pages. It has a vertical slide which carries the cutter saddle, and a horizontal table to which the work is fastened in the usual way. This table is borne in a saddle, on which it is revolved by worm gearing. Its speed of rotation is fixed at the right ratio with the speed of rotation of the hob by change gear and a swing plate, and a differential gear, which is visible in the engraving, is employed when spiral or helical teeth are being cut. The down feed is effected by a screw driven either by a pitch chain or, for adjustment, by the hand wheel at the top of the upright.

The form of the cutter head is shown pretty clearly in the illustration; it can be swung round to any angle in the vertical plane, a scale on its periphery marked in degrees serving for its adjustment. Half-degrees are not marked, as it is found that the operator can estimate such division with sufficient accuracy, the small amount of error likely to occur being negligible.

The machine can be used also for cutting gears with a mill, the cutter head being then set horizontal. An indicator is fitted for securing that the cutter shall be truly central, and end adjustment of the cutter head as a whole on the saddle with fine adjustment is provided. The indicator is a pointer which is placed on the work mandril, and tried first to one side and then to the other of the cutter.

Worm wheels can also be hobbed. The vertical feed is then cut out, and the table is fed forwards towards the worm until the correct depth is reached, when it knocks out automatically. This feed is also driven by a pitch chain. It will be observed that an inverted vee slide is used for the table. The machine illustrated—Fig. 36—is fitted for electric drive, the resistance box of the motor being visible on the right-hand side.

The bevel wheel planing machine made by Smith and Coventry, of Manchester, has not changed in any radical respect since we illustrated and fully described it in THE ENGINEER of August 24th, 1900, but it has undergone several minor changes, which have added to the ease with which it can be handled, and certain modifications of the original design will be noticed in the plan and elevation given in Fig. 35. An important improvement is the balancing of the former arms, which greatly reduces the labour of adjustment. As the machine is entirely different from any other on the market, we need make no apology for describing it again.

Two tools are used, one cutting each side of the tooth. They move backwards and forwards to effect the cut, and

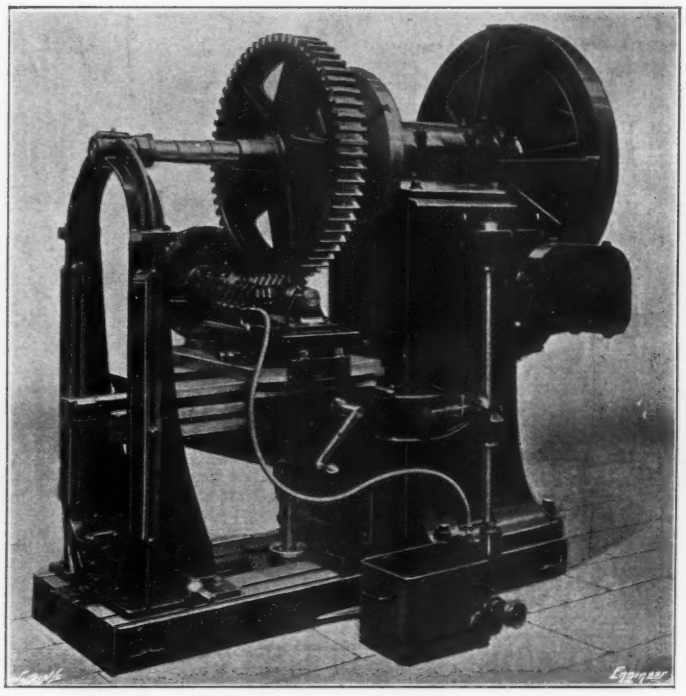


Fig. 28—GEAR HOBBING MACHINE—REINECKER

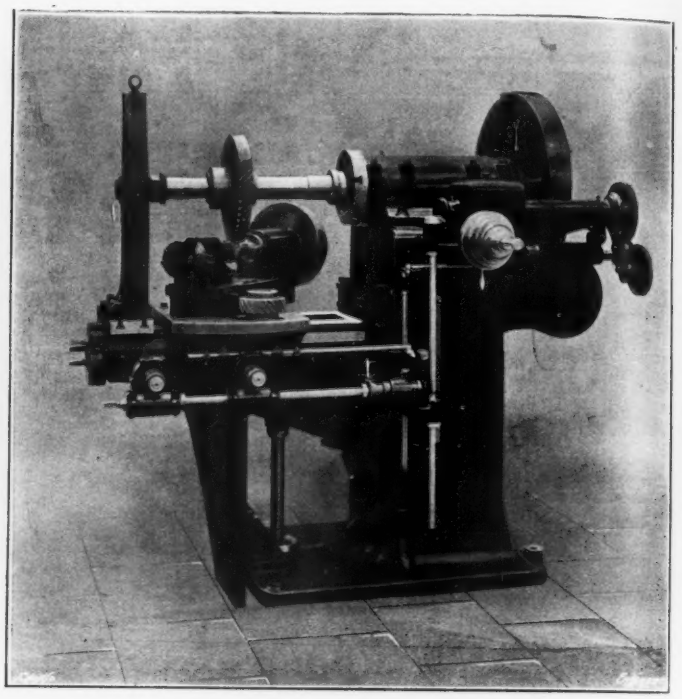


Fig. 29—UNIVERSAL GEAR CUTTER—REINECKER

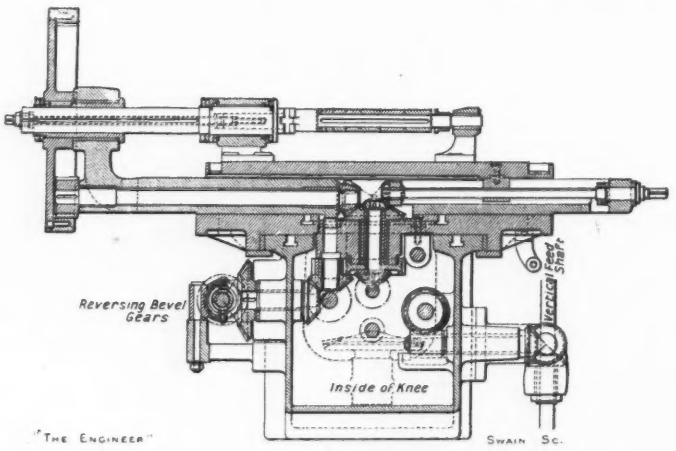


Fig. 30—SPINDLE DRIVE

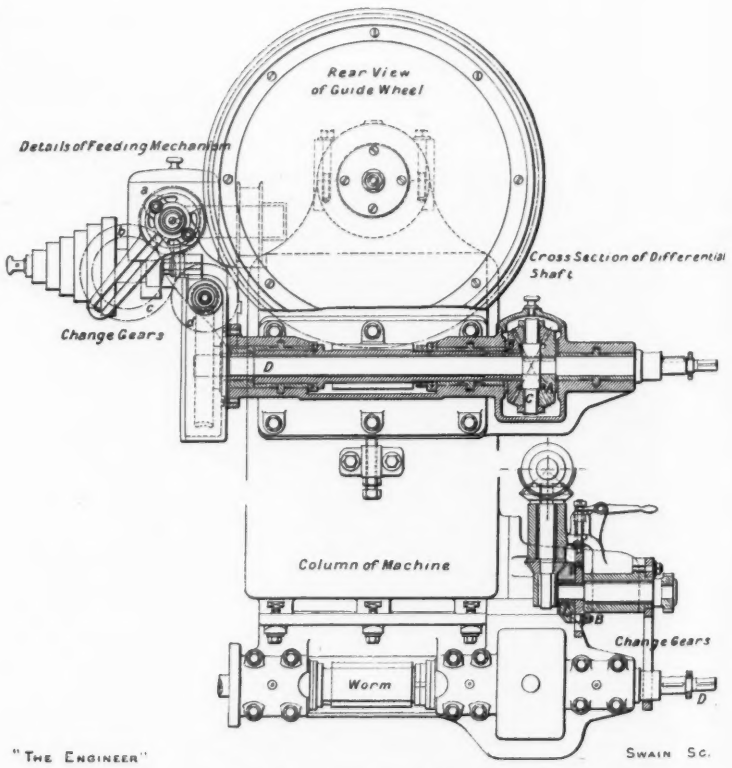


Fig. 31—DIVIDING GEAR

the distance between them is proportionately increased as the root of the tooth is approached. The gist of the invention lies in the novel means employed for increasing the space between the cutting edges of the two tools at the proper rate.

The illustrations show how this motion is obtained. In Fig. 35 the two cutting tools are marked A A. They are, we may say at once, straight pieces of steel some 3in. or 4in. long by an inch or so deep, and taper in cross section. The corner at the leading end on the narrow side is rounded to the shape of the fillet of the tooth being

shaped, and is the cutting edge. These knives are carried in two tool-boxes, which it is unnecessary to describe. Two cast iron slides B B are hinged at the centre X, and the tool-boxes slide to and fro on them, the cutting edges of the tools always moving in lines truly radial to the centre X. Motion is given to the tool-boxes by the connecting-rods C C, the crosshead D, and the adjustable

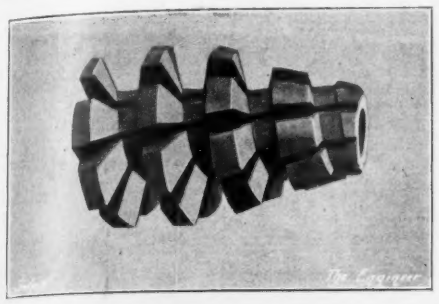


Fig. 32—TAPER WORM HOB

crank E. From this part of the machine the true taper of the tooth from back to front is obtained. Now for its shape in cross section.

On the two slides B B there are cast extensions terminating in quadrants. Rigidly bolted to these quadrants by the nuts shown are two pieces terminating in the pins G G. These pins enter blocks fitted into two slides H H. These two slides are connected by a system of links which forms a parallel motion. It will be better understood from Fig. 33. The same letters are kept.

Here, as the three points K L M on the centre line of the machine are fixed, it will be seen that if the long lever R L T is moved the two slides H and H will move in such a manner that they approach or recede from the

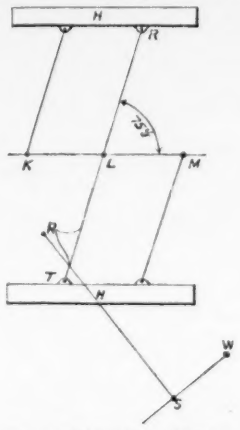


Fig. 33—PARALLEL MOTION

centre line by exactly the same amount, and keep perfectly parallel to each other. As they increase their distance apart they open out the slides B and B, and increase the distance between the cutting edges.

We have now to see how they are given this motion in the required amount and at the required time to produce the desired form of tooth. On the lever R L T there is an extension ending in a slot R, which carries a connecting-rod R S. The end S is locked at a specified position in a slotted link swinging round a centre W. The link is keyed to one of a pair of bevel wheels, one of which is associated with a quadrant seen in the plan. The quadrant has carefully cut teeth, which mesh with teeth cut on a stiff curved bar. This bar is locked to the carriage bearing the mandril, the dividing head, and the

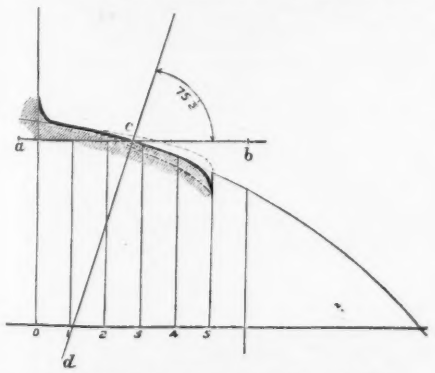


Fig. 34—DEVELOPMENT OF BEVEL TOOTH

blank. The carriage moves in a circular path around the centre, which is vertically below the cutting line of the tools. The carriage is moved by a worm revolving in a circular rack. It will be seen at once that simultaneously with the motion of the carriage the lever R L T is rocked, the slides H pushed further apart, and the distance between the cutting edges increased. It will be understood that as the blank moves further and further towards the slide, the distance between the two tools, always moving on lines radiating to centre X, is gradually increased. It now remains to see what the rate of increase is in accordance with that prescribed by an involute tooth odontograph.

Without entering into the theory of involute teeth and their construction by this instrument, it will be necessary to recall a few points. It will be remembered that involute teeth have a path of contact which is a straight line inclined to the line of centres of the wheels. The inclination of this line is to a certain extent optional In the odontograph it is taken at 75½ deg., and the contour of the tooth is described by a single curve described from a centre on this line with a radius of a quarter of the radius of the pitch circle of the blank. In Fig. 34 the outline of a tooth is shown shaded. The spaces between ordinates 0, 1, 2, 3, 4, 5 show increments of feed, whilst the height of the ordinate to the

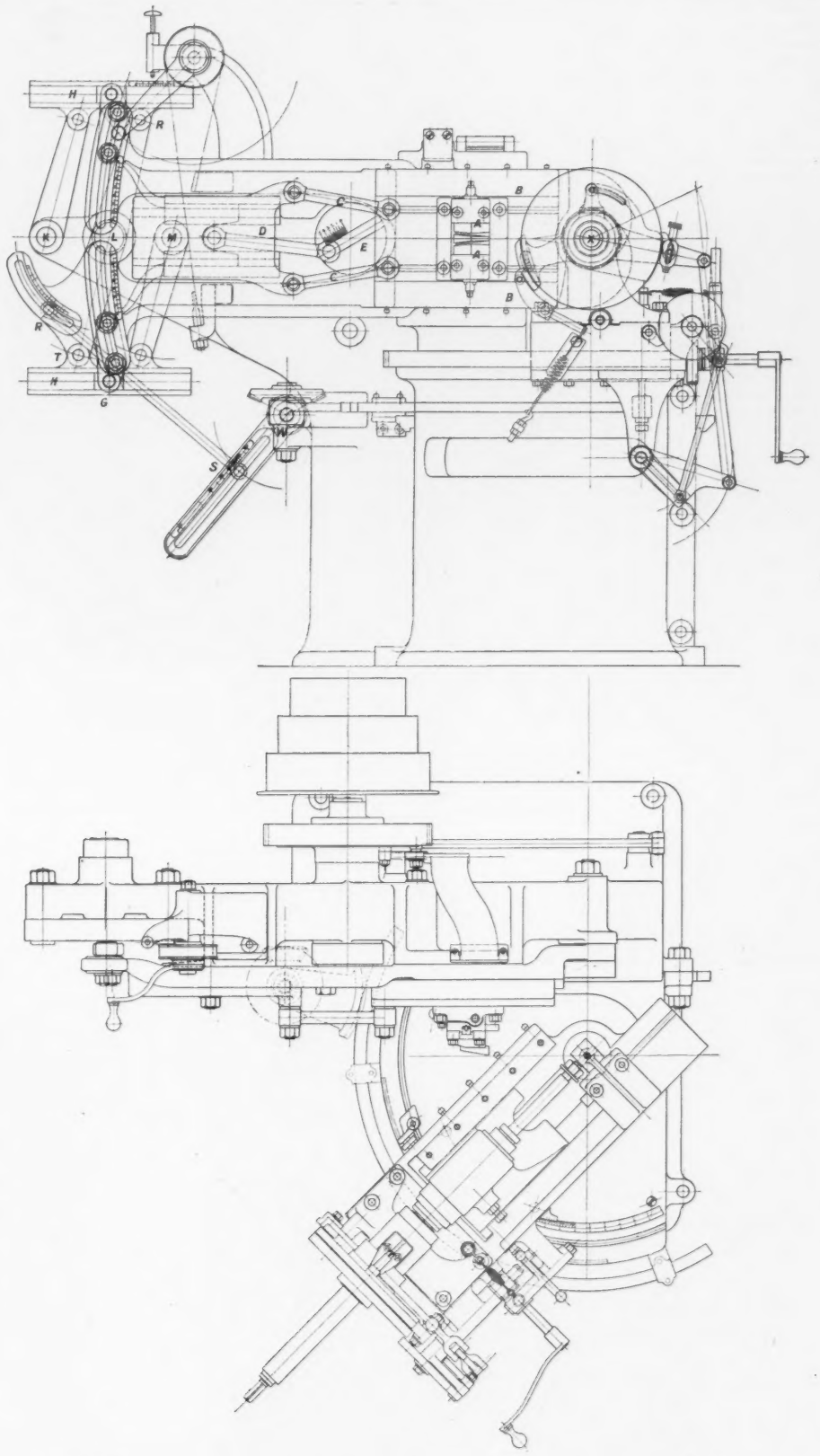


Fig. 35—BEVEL GEAR PLANER—SMITH AND COVENTRY

curve at any place shows the amount the slide *a b* is above or below the normal position in which it is shown. The diagram shows the two motions in one plane, but it will be understood that in the machine they take place in planes at right angles to each other. The length of the radius *c d*—it is virtually one-fourth the length from L to X in Fig. 35, though not actually, as for convenience of construction H is some distance above point R—is correct for equal pairs of all wheels; that is to say, for mitres, but for unequal pairs the radius would be different. To obviate the constructional difficulties which would be involved in a machine in which this length could be altered, the correction is made by giving the lever a greater amount of motion for the same rate of feed; that is to say, that whilst the distances 0, 1, 2, 3, 4, 5 remain constant, the length of the ordinates varies at either a greater or less speed, as required, a greater speed corresponding to a shorter radius, and a slower to a longer radius. This is shown greatly exaggerated in Fig. 34 in dotted lines. In practice it is obtained by sliding the end S of the connecting-rod R S in the slotted link, which is graduated for the purpose. For different pitches it is necessary, too, to alter the angle between the cutting tools. For this purpose the quadrants are also graduated.

The machine is driven by a single cone pulley, a cam actuating the table. A knock-out is fixed at the right position on the bed, to stop the motion of the table when the teeth have been cut to the full depth. The machine is used as follows:—The blank is fastened on the mandril, to which a suitable dividing gear is attached. Adjustment of the tool and the blank are made by gauges provided for the purpose. The dividing head is then set to make the wheel move forward one tooth for each stroke of the cutters. The feed comes in automatically. On account of the shape of the cam, it gradually increases for five strokes, and then remains constant for the remainder of the circumference, when it is again increased in the same manner. Thus it goes on till the majority of the teeth are cut completely to depth and shape. At

this point the feed knocks out automatically, but the blank continuing to revolve, the first five teeth have the extra material left on them cut off, and the wheel is complete.

The great virtue in the machine is, of course, that it generates a correctly formed tooth by very simple mechanism. A general view appears in Fig. 42.

Two sizes of automatic gear-cutting machines are made by J. Parkinson and Son, of Shipley. They are a 36in. machine cutting wheels up to 9in. wide, 3 diametral pitch, from the solid at one operation in steel, and a much heavier and more powerful machine cutting from 2½in. up to 48in. diameter by 10in. wide. Both of these machines are illustrated—the smaller machine by a front view—Fig. 45—the larger by back and front views and drawings—Figs. 48 and 49. The machines are of the vertical type, the blank being held in a vertical position on a horizontal arbor. The cutter advances beneath it, and the wheel is divided automatically by a worm wheel. The designs of the machine, it will be seen, are as simple as circumstances will permit. The division of the blank takes place in the ordinary way through a train of gearing, which is put into action on the return of the cutter slide. The wheels permit of all division up to 100, and all division except prime numbers between 100 and 400 being cut. The cutter is well supported between bearings, and its speed may be varied to suit the material and work in hand. The makers emphasise the fact that the worm shaft used for dividing does nothing else; it is not used for transmitting any other motion, and there is thus no danger of its receiving torsional strain. Safety mechanism to prevent the cutter coming into action, if a wrong division should by any chance take place, is provided.

We shall now turn to the larger machine, of which more particulars can be given. The column carrying the horizontal spindle and dividing wheel is in this, as in the smaller machine, cast solid with the bed. The cutter slide is guided along its bed by a guide 5in. wide by 23in. long, and is adjusted by a taper gib. The dividing wheel is 32in. diameter. The work spindle head is moved on the column by a screw actuated by a hand wheel brought and has four changes of speed—obtained by sliding gear—ranging between 25 and 75 revolutions per minute. The spindle is hardened and ground, and has adjustments for wear. The cutter feeds are obtained by change gears, and are twelve in number, the least being ·043in., and the greatest ·180in. per revolution of the spindle. The dividing mechanism is driven by friction, and has a graduated start and stop to avoid shock, and a safety device, to prevent the cutter coming into action should a wrong division take place. The divisions obtainable are the same as in the small machine, namely, all numbers up to 100, and all between that and 400, save the primes. The machine is driven by a single belt on fast and loose pulleys, which are incorporated in the design. Other details, such as the pump, &c., will be noticed in the photograph.

Fig. 36—GEAR HOBBING MACHINE—SCHUCHARDT AND SCHUTTE

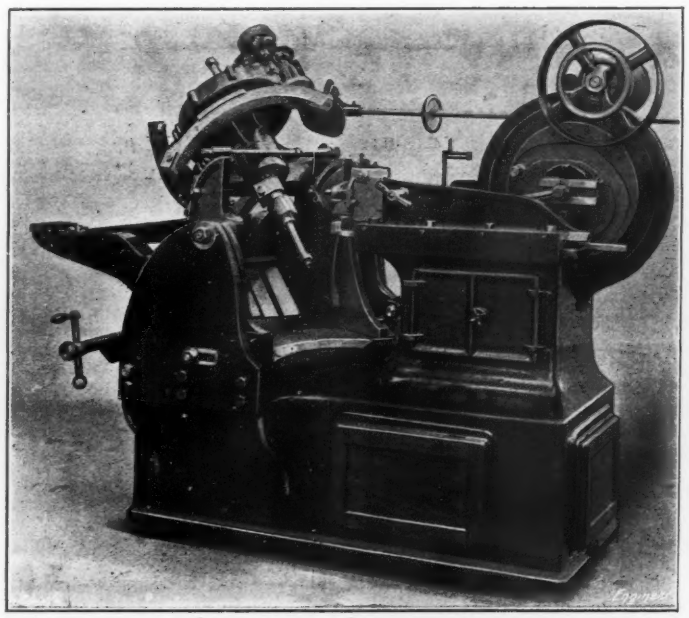


Fig. 37—AUTOMATIC BILGRAM GEAR SHAPER

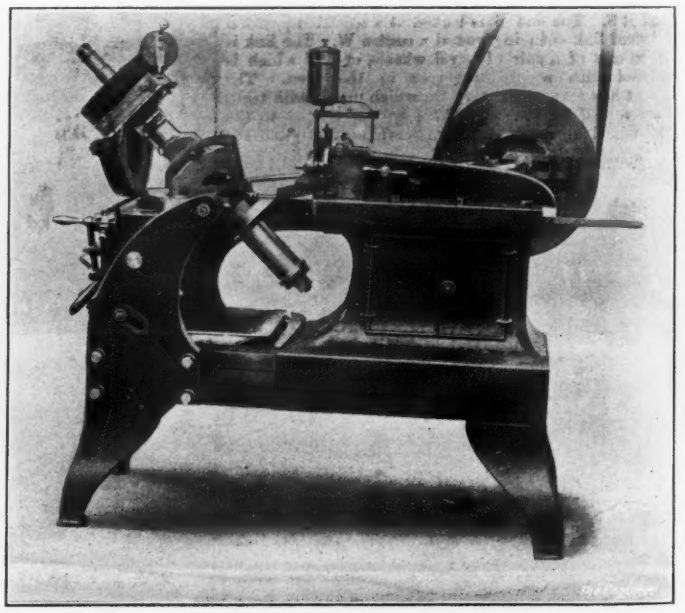


Fig. 38—BILGRAM GEAR SHAPER

down to a convenient position. A ball thrust takes the weight to render adjustment easy; the dial for fixing the depth of tooth accurately gives readings to $\frac{1}{1000}$in. The out-board support is hinged to its bracket, so as to facilitate the mounting and changing of work.

The cutter spindle is driven by worm and worm gear, and is retarded before coming to rest. In this way the sudden shock, due to the inertia of revolving pieces, is avoided, strain on the working parts of the machine is reduced, and greater accuracy and durability are secured. Provision is also made for intermittent spacing, a valuable safeguard against the unequal heating and consequent expansion of the gear being cut. In this way, on the first revolution of the dividing wheel, every fourth or every second space, as previously determined, may be cut, the intervening spaces being cut at successive revolutions of the dividing wheel. The intermittent spacing is controlled from the multiple division box—shown in Fig. 39—and incidentally there is the advantage of reducing the number of change wheels required for indexing.

As an additional safeguard against inaccuracies in division, such as may arise from the failure of any parts of the machine, an automatic arrangement is provided for arresting the feed of the cutter slide. This is incorporate as part of the machine, and is not a separate attachment. No adjustment of this is required for variations in the number of teeth to be cut, or in the pitch, or in the diameter of the gears, but only to suit different positions of the gear blank on the work mandril.

Referring to Fig. 39, the fast and loose pulleys shown at V, V¹ receive the belt from the line shaft. The pulley V is keyed on a shaft which passes through the gear box, of which a plan section is given, and by the sliding gears shown, the speed of the driving shaft W may be varied. The shaft W runs alongside the machine, and, through spiral gears, drives the cutter spindle and feed only.

The pulleys X, X¹, receive a second belt from the line shaft, and are used for driving the return motion of the cutter slide and the indexing mechanism. Pulley X revolves constantly loose upon its shaft, but may be connected by the sliding clutch shown to shaft Y, end view, which carries chain pinion Y¹, which in turn drives—by means of a Renold silent chain—wheel A between the friction discs shown. The friction discs are keyed to the shaft B, on the end of which is fixed a bevel pinion gearing with a bevel wheel C, to the boss of which is fixed an elliptical gear D.

C along with D revolves loosely on the change gear shaft E, and the elliptical gear D engages with a corresponding gear F, which is keyed to and revolves with a stop shaft G. On the boss of gear F is mounted the spur gear H, which engages with the spur gear I keyed to the shaft E. Motion is thus conveyed from the pulley X through the chain wheels Y¹ and A, bevel gears, elliptical gears, and spur gears, to the change wheel shaft E.

To obtain the number of divisions required, suitable change wheels are selected and mounted on the swing plate shown in the side elevation Fig. 39. These connect shaft E with shaft Z.

The dividing mechanism is set in motion at the end of the return stroke of the cutter slide by the withdrawal of the lever J, which thus releases the stop shaft. This allows gear A and friction discs, shafts B, E, G, and Z, to rotate—the last-named driving the vertical worm shaft—until the stop shaft has made one revolution, when its movement is again arrested by the lever J.

The stop shaft G is continued to the other side of the machine and carries a pinion, which has fifteen teeth, and engages with a wheel having sixty teeth, so that the gear ratio is 1:4. On this wheel is fixed a plate carrying four adjustable plungers, which may be set in or out of position to operate a lever, which is keyed along with the stop lever to the shaft. When all the plungers are set in, the stop shaft makes only one revolution for each division, but if the four plungers are set out they will, by coming in contact with lever, hold the stop lever from contact

We are indebted to the makers for the following clear description of the indexing mechanism, the most important feature of gear-cutting machines, and for the drawings.

The mechanism for dividing or indexing is so arranged that the movement commences gradually, is accelerated, with the disc on the stop shaft, and the worm will revolve continuously. If two opposite plungers, for example, are set out, and the intermediate plungers are in the inner position, the stop shaft will make two revolutions for each division, and if only one plunger is in the inner position the stop shaft will make four

revolutions for each division. Fig. 41 shows the dividing worm carried on a sliding bracket, and driven by spur gears from the vertical shaft. In this way, and by releasing the lever nut, the worm may be disengaged from the worm wheel, as is sometimes required, for testing the truth of gear blanks previous to cutting.

We are, as we have already said, sorry that so few makers have seen their way to give us similar particulars and drawings, as it would have been exceedingly interesting to compare the different methods of arriving at the same end. It will be admitted that Messrs. Parkinson's method is very neat and ingenious, and the introduction of the elliptical gear for giving a gradual start and stop to the dividing mechanism is an excellent point.

Three machines, constructed by G. Wilkinson and Sons, of Keighley, are illustrated in Figs. 44, 46, and 47. The last is a large machine, of which the arrangements are so obvious that little or no description is called for. It will take blanks up to 12ft. diameter by 3in. pitch and 16in. face, and will cut straight, bevel, and worm teeth. The dividing wheel and the worm are ground into accurate contact, and the spindle to which the wheel is keyed has a solid flange at the other end which carries the face-plate. The cutter spindle has conical adjustable bearings, and the lower bracket can be slid out of the way to allow of cutters being put on. It will be seen that the cutter head is carried on a swivelling slide, which allows of bevel wheels being milled. The second machine—Fig. 46—is of much smaller size, and is fully automatic. It takes wheels up to 18in. diameter and $\frac{1}{4}$in. pitch. The dividing worm wheel is 14$\frac{1}{2}$in. diameter, and has 120 teeth of $\frac{3}{8}$in. pitch. Fig. 44 shows an automatic horizontal rack cutting machine. It takes racks up to 6ft. 6in. long, and will cut to a maximum breadth of 36in. The cross slide has vertical adjustment of 9in., and the saddle has a variable self-acting feed of 40in., and has a quick return motion. The number of turns of the dividing handle can be regulated by a chain attached to the carriage, which releases the dividing gear at the end of the return traverse. The dividing handle shaft is connected by change wheels to the accurately cut lead screw, and racks up to 1$\frac{1}{4}$in. pitch may be machined.

The Oerlikon bevel-gear planer, Fig. 43, is made at Zurich, and sold in this country by C. W. Burton, Griffiths and Co., of Ludgate-square, Ludgate-hill. It is one of the few machines with which we deal in which a former is employed, and it can thus cut teeth of any design that may be desired. All the forming motions are embodied in the work carrier, the cutter being a suitably ground shaping tool, which has no other motion than a slow cut and a quick return in a straight line. A slide, which is a permanent part of the machine, is placed directly beneath the ram, and is provided with a hard steel face at its "business end." By its means the tool is very readily adjusted for depth.

The centre of interest of the machine is the work carriage. This consists of a U-shaped casting supported between two horns on bearing about which it can swing in a vertical plane. Standing up vertically between the two limbs of the U is the spindle or mandril on which the blank is fastened. To the lower part of this spindle a curved casting is attached. On the lower end of this casting the dividing mechanism is mounted, whilst on the upper part the former is fastened. The "former" is simply an enlarged tooth, and the position it holds relatively to the blank is such that if the sides of any completed tooth were prolonged they would exactly coincide with the "former." Hence one former will do for all wheels of the same pitch. The cutting corner of the tool corresponds also precisely with the former, and the same slider that is used to adjust its position gives also the means for fixing the steel knife-edge which bears on the contour of the "former." The method of producing a tooth will now be obvious. One side is done at a time all round the wheel, and then the other, so that two revolutions of the blank are required to complete the work. A weight pulls the end of the curved casting in one direction, so that the former bears against the knife-edge, and the feed is effected by swinging the whole U-frame in its trunnions. The combined upward and sideway motion results in the production on a small scale of precisely the same shape as the "former" has.

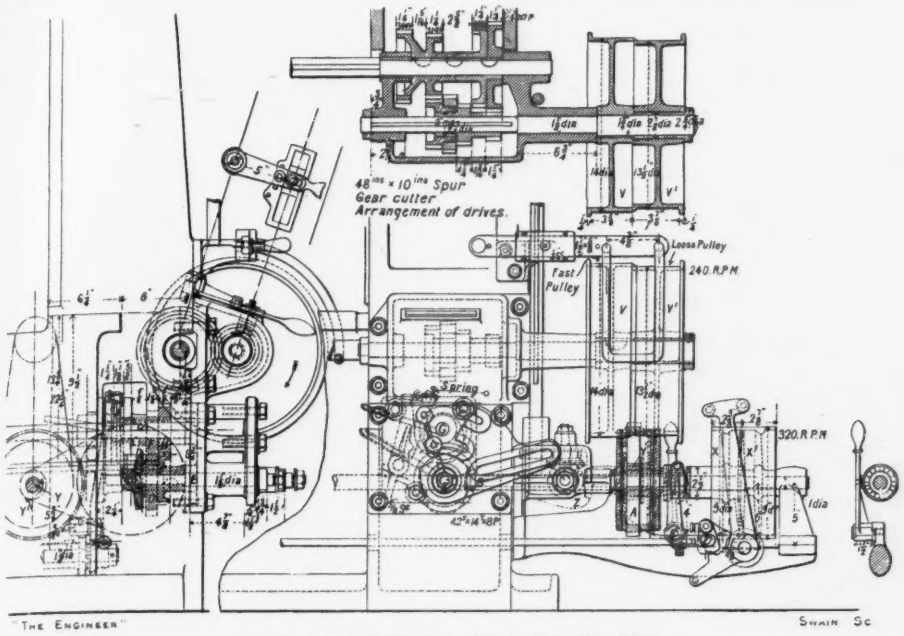


Fig. 39—DIVIDING GEAR—J. PARKINSON AND SON

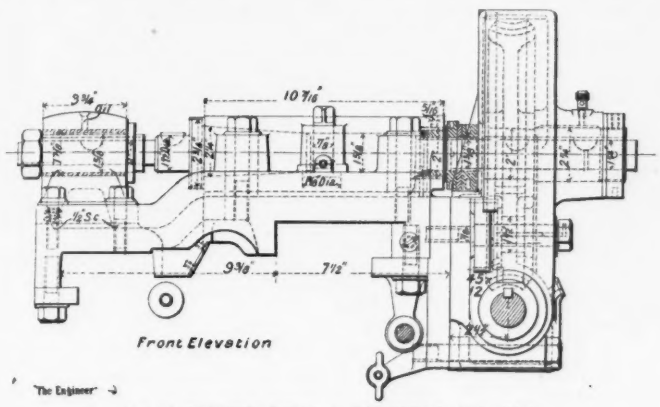


Fig. 40—SPINDLE DRIVE—J. PARKINSON AND SON

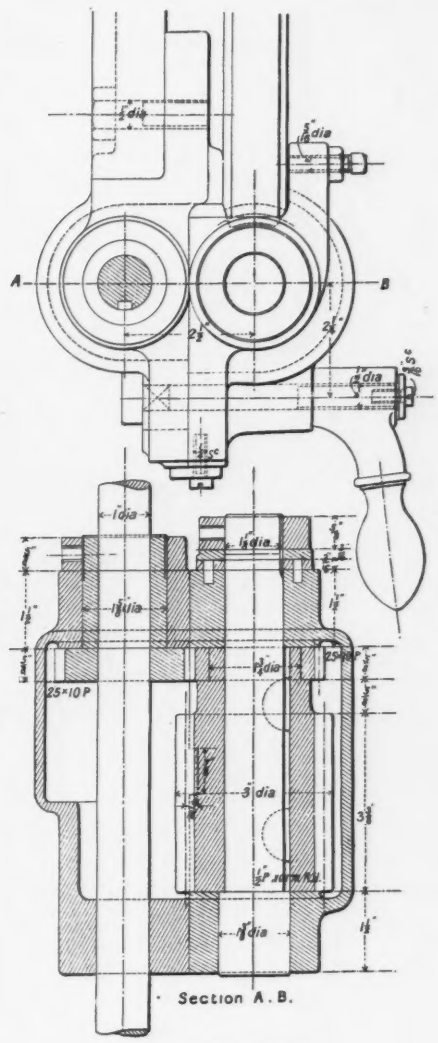


Fig. 41—DIVIDING WORM

The machine is fully automatic up to a point; that is to say, it cuts all round a wheel on one side of each tooth, but before the other side can be done the knife-edge on the opposite side has to be brought into contact with the former, and the direction of pull of the weight changed.

The dividing mechanism itself is placed at the back of

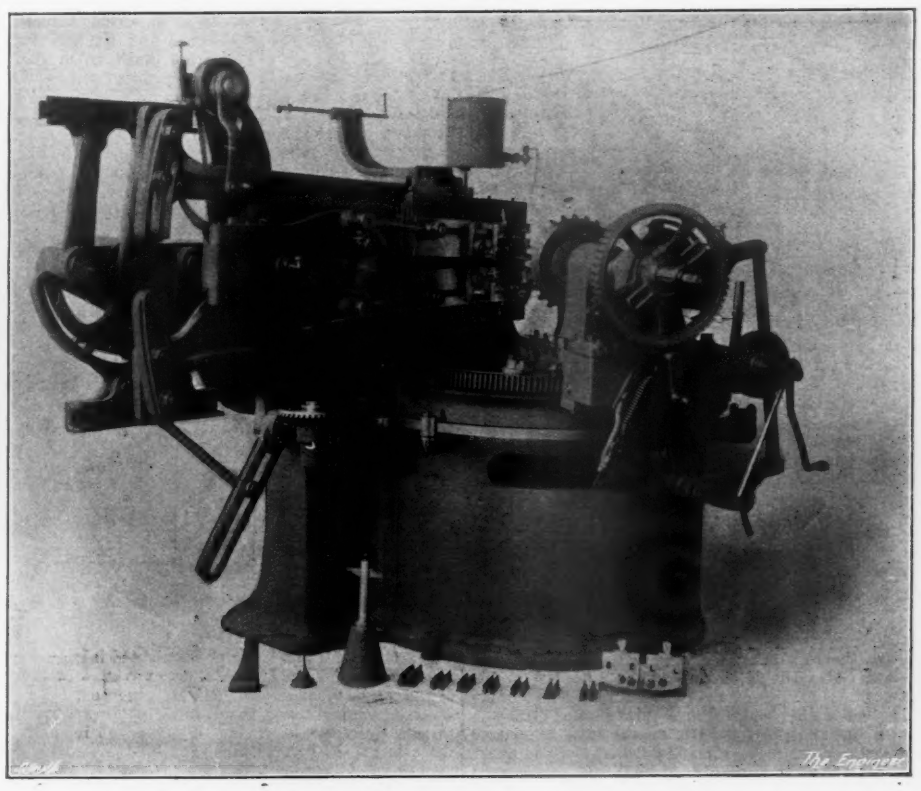


Fig. 42—BEVEL GEAR PLANER—SMITH AND COVENTRY

the machine, and the motion is brought through the pedestal by means of a telescopic and universal-jointed rod, which, through a pair of bevel wheels and pinions, drives a worm and wheel at the lower end of the mandril. The worm acts as a lock, and prevents any back lash or play in the blank. It would be impossible to explain the automatic mechanism without a full set of drawings,

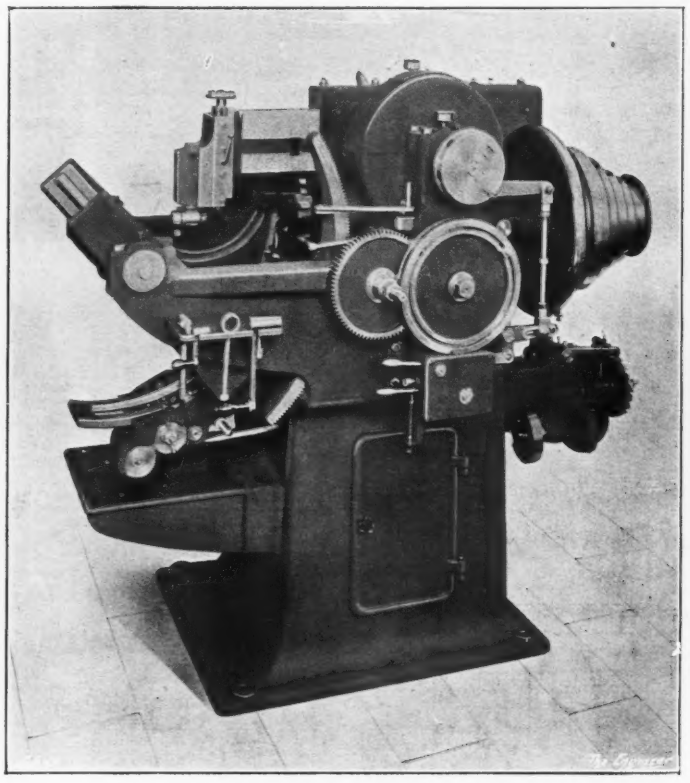


Fig. 43—OERLIKON BEVEL GEAR PLANER

and these we have been unable to obtain. The machine is driven by a five-step cone through a worm and wheel, and works at a high speed.

For the Gleason automatic bevel gear shaper Buck and Hickman, of Whitechapel-road, are the agents. This machine is illustrated by back and front views—Figs. 53 and 54—which bring out very clearly the main feature of its design. The old Gleason machine, it will be remembered, employs a former; this machine generates the teeth. The tools are carried in boxes on a pair of slides which can be set at the proper inclination to each other that corresponds with the taper of the tooth to be cut. The tools are straight-sided, as in the Nardin machine, and they cut opposite sides of the same tooth, but they cut alternately. Each tool-box is provided with a rack gearing with a pinion which rotates alternately in opposite directions, and one box is thereby

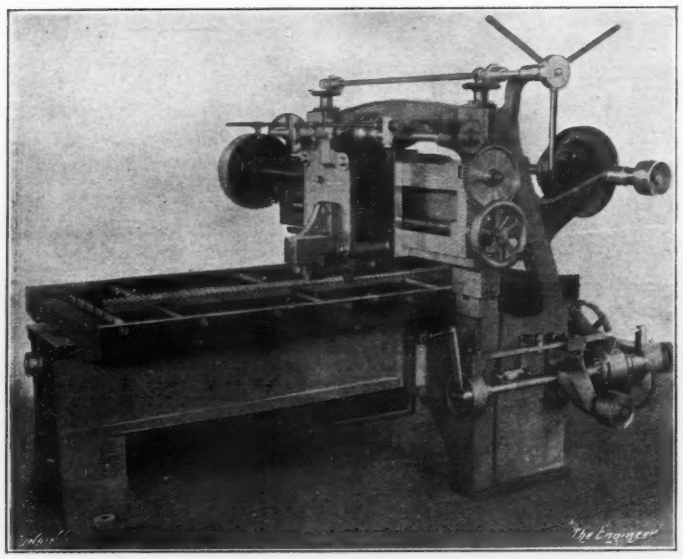


Fig. 44—RACK CUTTER—G. WILKINSON AND SONS

driven to the right when the other goes to the left, and *vice versâ*. The driving pinion occupies a position on the geometrical centre line of the machine, so that not only can the two slides change the angular distance between them without affecting the drive, but the angle being fixed the two slides can move up and down as a whole about the pinion. The cutter slides, and all the parts connected with it, are mounted on a substantial bed-plate, and are capable of movement in a horizontal plane to make the adjustment for the gear angle, and at the same time the plate on which the slides are mounted can move up and down in a vertical plane. The driving motion for the tools is brought up through the centre of the machine to bevel gears enclosed by the covers seen in Figs. 53 and 54, and is carried horizontally to a train of wheels, of which the casings can be seen in Fig. 53. The rearward pair of wheels in this view is changeable, to vary the cutting speed or number of strokes per minute. The wheels drive a disc provided with a slot and screw for varying the length of stroke. From the crosshead in the slot extends a connecting-rod in which teeth are cut. These teeth gear with an extension of the pinion already mentioned as situated between the tool slides. As the disc revolves the connected rod reciprocates and sets the pinion oscillating, and it in its turn drives the two tool slides to and fro, but always in opposition to each other.

The work is mounted on a spindle, much as in other machines, but to the spindle is keyed a long semi-circular arm embracing half the machine. A connecting-rod descends from this arm to the feed mechanism, which, starting from the centre, first raises it, then lowers it, and finally returns it to the centre, the complete operation producing one tooth. The connecting-rod and its connections are best seen in Fig. 54. The arm on which its lower end is pivoted is known as the radius arm, and it has a screw and slot to allow of variation of the stroke. The arm, it will be observed, is actually a bell crank lever, and the second member can be distinguished in the engraving—Fig. 54. At its extremity there is fitted a roller, which runs on the periphery of a cam of special form. The form is designed to vary the rate of feed according to the position of the tool. Thus, when near the pitch line, when the cut is heaviest the feed is slowest, but as the point of the tooth is reached and the cut is lighter the rate of feed is materially increased. The generating motion is

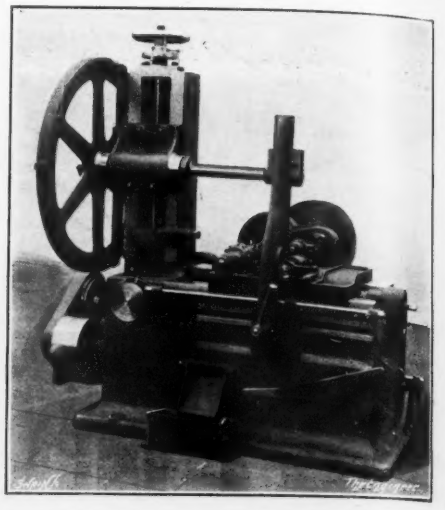


Fig. 45—PARKINSON'S GEAR CUTTER

derived from this arm. Its mechanism consists first of a permanent segment of a crown wheel fastened to the extremity of the plate carrying the cutter slides, and, secondly, of interchangeable quadrants which gear

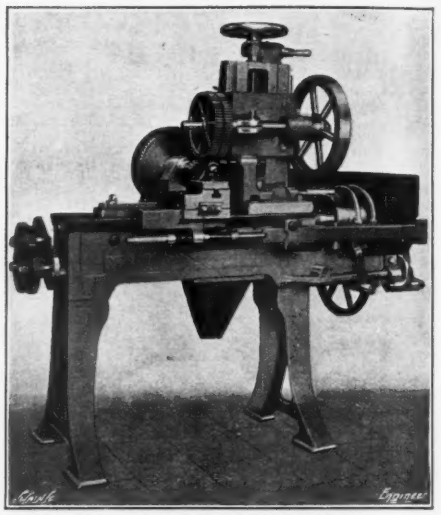


Fig. 46—WILKINSON'S GEAR CUTTER

correctly with the first quadrant, and are bolted to the semi-circular arm. It will be seen that by moving the arm in the manner already described this second segment will drive the first; but with the first the tools move, and with the second the blank moves. These segments act precisely as if the teeth of the gear being cut were prolonged out to where the loose segment is, and there geared with the permanent one. It will be seen that the correct rolling motion for the development of an involute tooth is obtained in this way, the blank rotating, and the cutters moving harmoniously with it, owing to the action of the segments.

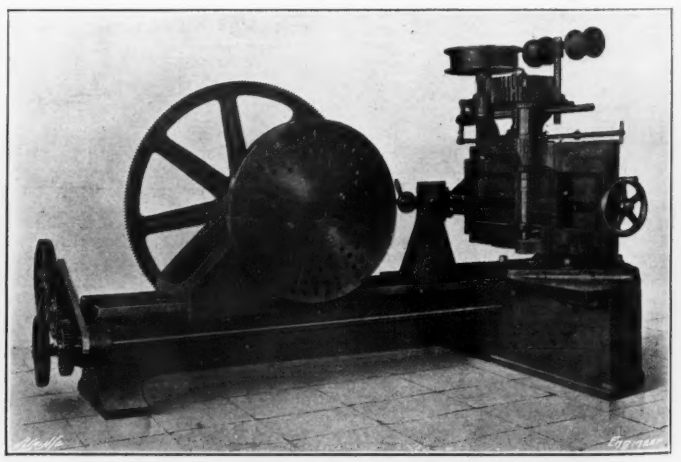


Fig. 47—12-FOOT GEAR CUTTER—G. WILKINSON AND SONS

The Brown and Sharpe gear cutter is probably the

most widely known of all machines of the kind, and we illustrate three different sizes, all of the latest type, and one of them—Fig. 58—fitted with a new safety device, which prevents any chance of the cutter starting its return stroke before the indexing is complete. The agents in Great Britain for these machines are also Buck and Hickman, of Whitechapel-road.

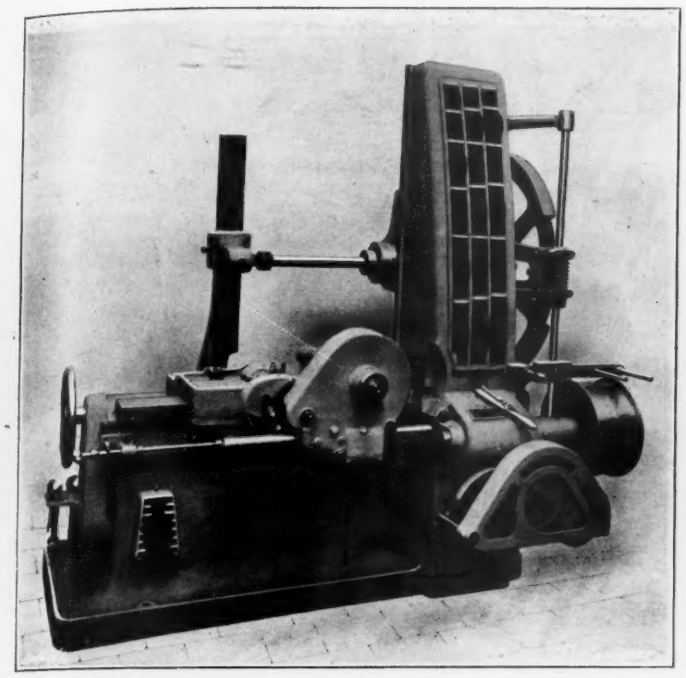
The No. 3 automatic machine is shown by back and front views—Figs. 55 and 56. It takes wheels up to 26in. diameter by 8in. face, and up to 5 diametral pitch in cast iron. The spindle has eight changes of speed between 28 and 168 revolutions per minute; there are twelve changes of feed, beginning at ·015in. and ending at ·147in. per revolution. A dial, divided to thousandths, is provided for vertical adjustment, which is made easy by a ball thrust on the elevating screw. The indexing mechanism acts independently of the cutter speed. It allows of all wheels from 12 to 50 teeth, and all between 50 and 400, except prime numbers, being cut by use of change wheels.

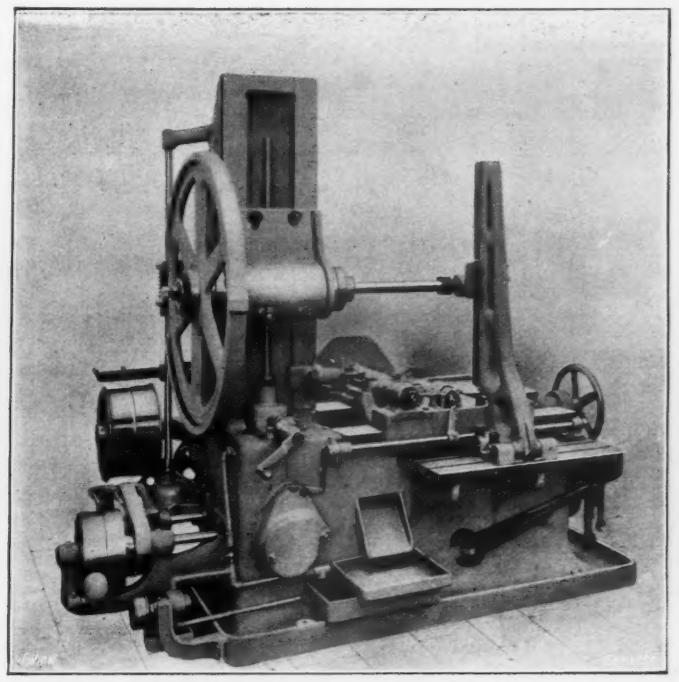
The No. 6 machine—Fig. 57—is of substantially similar design. It has six changes of speed, 12 to 50 revolutions per minute, obtained by change gears; twelve changes of feed, between ·05 and ·373 per revolution; and will cut all the same numbers of teeth as the smaller machine, but will take work up to 60in. diameter by 12in. face, and 1¾ diametral pitch in cast iron.

Finally, we show the very latest machine brought out by this firm, the No. 13. It is not a large machine, cutting wheels up to only 18in. by 4in., but it is fitted with the new safety mechanism to which we have already referred, and on the table is mounted a special fitting for cutting bevel gears. The gears have to be milled, and cutters of special form, made by Brown and Sharpe, are used for the purpose. The large end of the tooth is always made to the correct dimensions, and by setting the cutter a few thousands off it is possible to bring the smaller end so nearly correct with a short face angle as to be almost negligible. This machine has eight changes of speed and twelve changes of feed, and in its general characteristics is similar to the No. 3, except that it is a good deal smaller.

We shall now deal briefly with some of the details of these machines which apply equally to all, but the makers do not care to publish a full set of drawings, and without them it is not possible to give a full account of this ingenious machine. A section of the spindle is given in Fig. 50. It has, it will be seen, three diameters, of which the smallest takes the cutter; the second fits the taper bush, and the third fits the sleeve. A rack is cut on the outside of this sleeve, and a worm gearing with it, which is turned by a key, provides the means for adjusting the spindle endwise to bring the cutter absolutely central.

To the spindle is keyed a wheel driven by a well-lubricated worm. The work spindle is shown in section in Fig. 51, where A stands for the dividing worm wheel. This sketch also shows clearly the manner of chucking the work, B being a split bush which is moved on or off the taper part of the arbor by the nuts on either side of it. The blank is held firmly by expanding this bush in it, and then by turning the hand wheel C the arbor and collet are drawn into the taper hold in the spindle, and all is firm. A section of the feed and reversing gear-box is given in Fig. 52. The feed is effected by the worm A when the clutch B is in one position; in the opposite position the reverse is in gear, and the cutter head returns at a high speed. The dividing wheel of these machines is made in a single part, not divided like those by Loewe, or Darling and Sellers, but it is claimed that an equally high degree of accuracy is obtained. The locking disc of the indexing mechanism makes one, two, or four





Figs. 48 and 49—48-INCH GEAR-CUTTING MACHINES—J. PARKINSON AND SONS

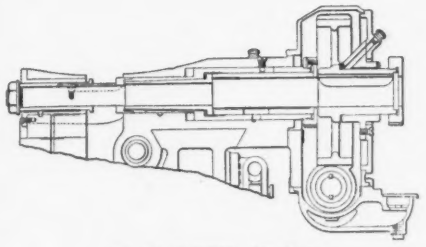


Fig. 50—CUTTER SPINDLE

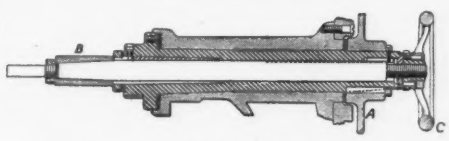


Fig. 51—WORK SPINDLE

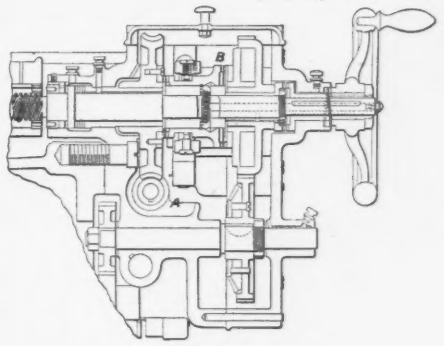
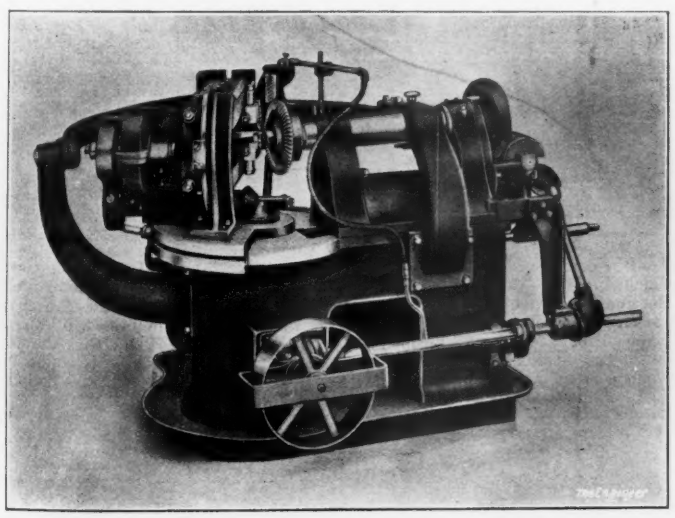


Fig. 52—GEAR BOX



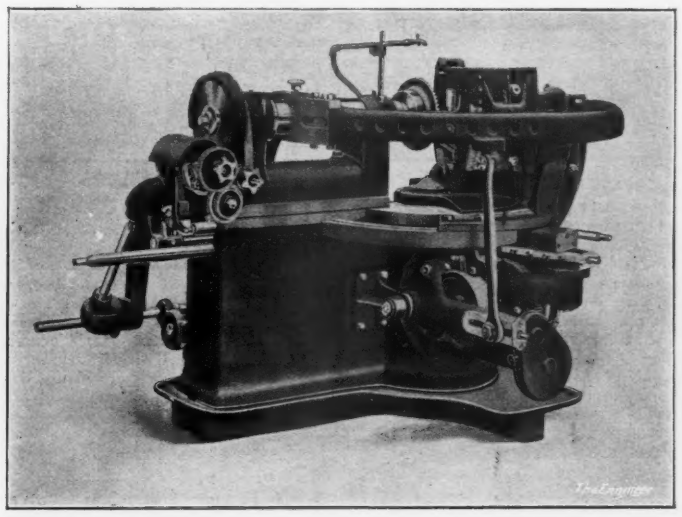
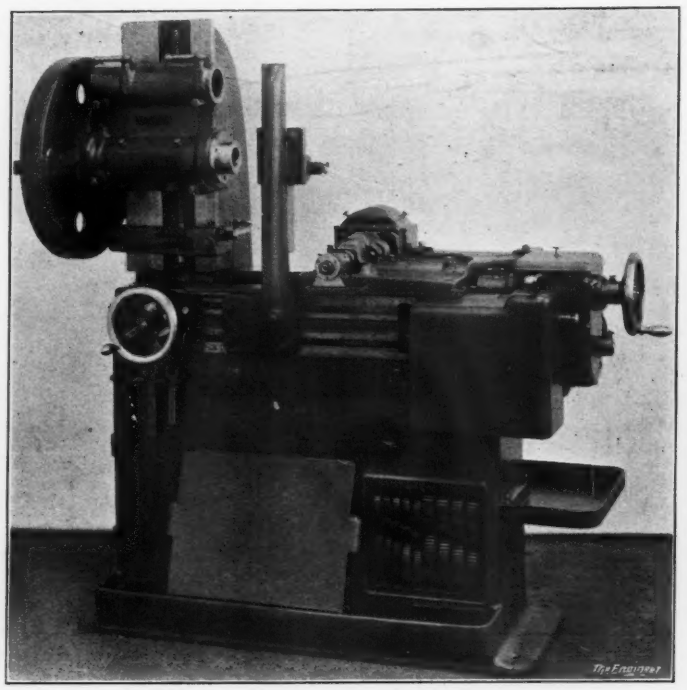
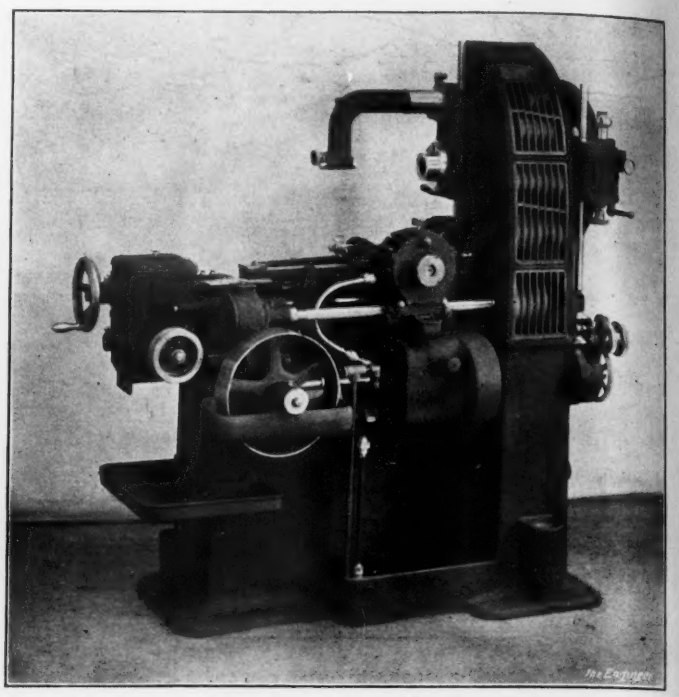


Fig. 53 and 54—GLEASON AUTOMATIC BEVEL GEAR PLANER

turns before the catch drops in, the change being made by a small spring knob.

The indexing mechanism is entirely positive, no friction drive of any kind other than the belt that operates it being employed. It starts up slowly, and comes to rest gradually, so that it operates without shock or jar, and it is driven by a separate belt quite independently of the cutter drive. The worm that drives the index wheel can, when desired, be disengaged and the spindle turned by hand, or the index driving mechanism can be disconnected from the worm, allowing the work to be adjusted if it is desired to re-cut some of the teeth. A new machine of small size, known as No. 12, has been recently brought out by Brown and Sharpe. It is intended only for light work, and cuts spur or bevel gear up to 12in. diameter and 8in. face up to 10 pitch. The cutter spindle in this little machine is driven by an endless chain, which runs along the back of the machine. A bight in it is taken up by two-jockey pulley and led round a sprocket wheel on the end of the cutter spindle. This arrangement, of course, leaves the carriage free to move upon the bed, but the usual sliding gears are all dispensed with. The drive for the quick return of the cutter slide is independent of the feed and speed of the cutter itself. The machine is arranged for a constant speed drive, all the changes of feed and speed being secured in change-boxes by the movement of levers and index slides. The machine presents the peculiarity that the dividing worm wheel is not visible, being entirely enclosed in the work spindle head, where it is thoroughly protected from dust and dirt. The driving worm is fastened to its shaft by a friction clutch, and it can be instantly loosened to allow the blank to be turned by hand. In this machine there are ten changes of speed, ranging between 30 and 175 revolutions per minute, and twelve changes of feed, the slowest 1¼in., the highest 10in., per minute. Bevel gears are cut on this machine, not as in the other described, by altering the inclination of the cutter, but by inclining the work. For this purpose the work spindle head is so mounted that it may be swivelled to any angle, and its periphery is graduated all round to half degrees.





Figs. 55 AND 56—No 3 AUTOMATIC GEAR CUTTER—BROWN AND SHARPE

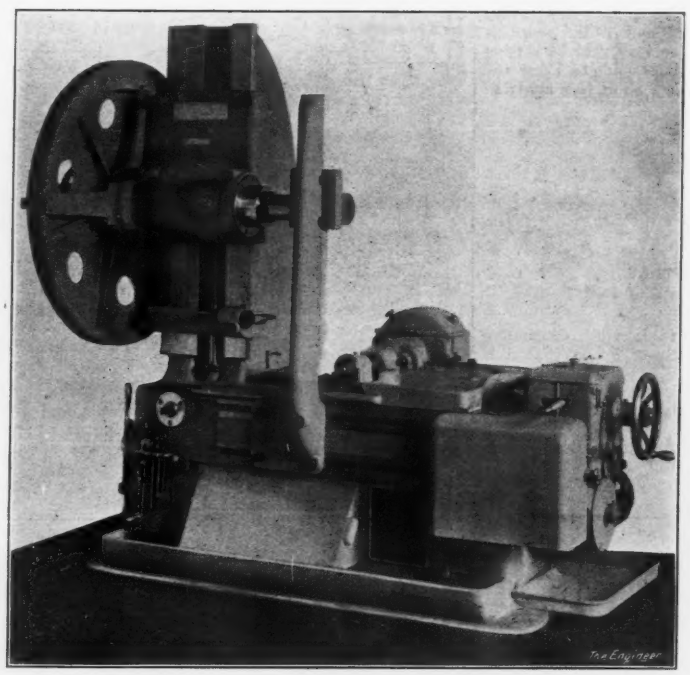


Fig. 57—No. 6 AUTOMATIC GEAR-CUTTER—BROWN AND SHARPE

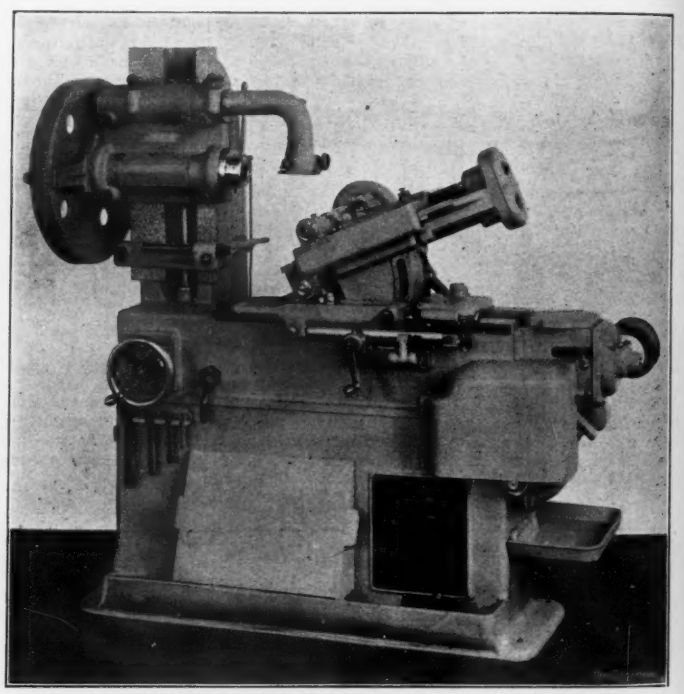


Fig. 58—No. 13 AUTOMATIC GEAR-CUTTER—BROWN AND SHARPE

MACHINE TOOL DESIGN.

By Professor J. T. Nicolson, D.Sc., M. Inst. C.E., and Mr. Dempster Smith.

No. XXV.*

C. Application to spindle bearings.—In endeavouring to apply the theoretical explanations and experimental results which have been discussed in the last two articles to the proportioning of the bearings for a lathe spindle we have two extreme conditions to provide for.

First, the bearings must keep cool when the spindle is running at its *highest* speed of revolution and under the heaviest load it will be called upon to sustain, *e.g.*, when carrying a heavy job between centres, and running at polishing speed.

Second, when taking a heavy cut, or carrying a heavy piece of work at a *slow* speed of rotation, it ought to be possible to prevent the metallic contact of journal and brass from taking place, which has been above described, by always retaining a film of oil between the same at every part of the circumference.

With reference to the *first case*, we have to consider how much heat is generated by the viscous resistance opposed by the oil to the rotation of the shaft, in what manner this heat is dissipated, to what temperature the bearing will rise in actual running, and what law connects the temperature at which the journal may safely run with the pressure and the speed.

The heat generated is obviously equal to $\frac{\mu \, P \, \pi \, d \, N}{12 \, J}$ thermal units per minute, if d is the journal diameter in inches, P the load in pounds, μ the coefficient of friction, and N the number of revolutions per minute.

If the heat dissipated by radiation from the surfaces of the housing and shaft be, as usually assumed, proportional to $d\,l$, the projected bearing area, and to θ the temperature difference between bearing and external air; then, when the temperature of the bearing becomes steady, we shall have (e being the emissivity coefficient)

$$\frac{\mu \, P \, \pi \, d \, N}{12 \, J} = e \, d \, l \, \theta. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

In the standard text-books—*e.g.*, Unwin's "Machine Design," vol. i., page 240—it is usually assumed *that whatever may be the diameter or length of the proposed journal the value of μ will remain constant.* In that case:—

$$l = \frac{\mu \, P \, \pi \, N}{12 \, J \, e \, \theta} = \frac{\mu \, \pi}{12 \, J \, e \, \theta} \, P \, N = \frac{P \, N}{\beta} \quad . \quad . \quad . \quad (16)$$

which means that the length of the bearing must increase with the load and the revolutions.

As a matter of experimental fact, however, μ is by no means constant. It depends on speed, pressure and

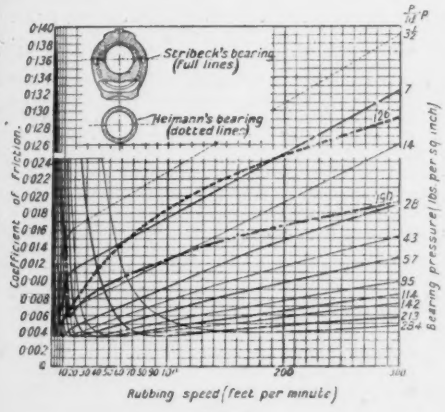

Stribeck's bearing (full lines)
Heimann's bearing (dotted lines)
Coefficient of Friction.
Bearing pressure (lbs. per sq. inch)
Rubbing speed (feet per minute)

Fig. 96

temperature, and, as we have already seen, we may take it to follow the law:

$$\mu = 1{\cdot}8 \sqrt{v/\theta \, p} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

If, then, we insert this value in (15), we obtain, since

$$v = \frac{\pi \, d \, N}{12}, \quad \therefore - \frac{e \, P \, (\pi \, d \, N)^{3{\cdot}2}}{12^{3{\cdot}2} \, p \, \theta \, J} = e \, d \, l \, \theta.$$

With $e = 1{\cdot}8$, $P/p = l\,d$, and $J = 778$, we get

$$\theta^2 = \frac{(d \, N)^{\frac{3}{2}}}{3400 \, e} \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

To determine the value of e, the emissivity coefficient, we may apply this formula to Stribeck's results from his Sellers bearing (see his figure 5 Z. d. V., September 6th, 1902). This bearing of diameter 2·76in. attained—according to that figure—after running for three hours at 760 revolutions per minute, a final temperature of about 140 deg. Fah. Therefore $\theta = 80°$ F.

Hence, from $e = (d \, N)^{3{\cdot}2}/7 \, \theta^2$ we obtain:

$$e = \frac{(2{\cdot}75 \times 760)^{3{\cdot}2}}{3400 \times 80^2} = 1/220 \text{ B. Th. U.} \quad . \quad (16)$$

dissipated per square inch of projected bearing area per minute per degree difference of temperature Fah., between the bearing and the outer air.

Thus the formula for θ, the final rise of temperature of a bearing above its surroundings, becomes:—

$$\theta = \frac{(d \, N)^{3{\cdot}4}}{\sqrt{3400 \times 1/220}} = \frac{(d \, N)^{\frac{3}{4}}}{\sqrt{156}},$$

or, in round numbers:—

$$\theta = \frac{(d \, N)^{\frac{3}{4}}}{4} \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

Expressed in words, this means that the steady or finally assumed temperature of a bearing of given diameter is greater the greater the $\frac{3}{4}$ power of the revolutions, and is greater for a given speed the larger the $\frac{3}{4}$ power of the diameter. *It is, however, quite independent of the length of the journal.*

We cannot, therefore, hope to lower the terminal temperature by lengthening the bearing. The heat generated increases as fast as the area for dissipating it does; for although by lengthening the journal the bearing pressure is diminished, yet since μ varies inversely as p, the frictional resistance and the heat generated are *pari passu* increased.

We know, however, from experience, that journals must be made long for high speeds, and the above conclusion seems at first sight to conflict, not only with the text books, but also with practice, and so to be paradoxical.

The explanation is as follows:—Whilst it is true that the final temperature to which a bearing will rise after a long run under a given load and with a given lubricant, depends only on the diameter of the spindle and on the speed of revolution, and not at all upon the length of the journal, we have to remember that *if that finally attained temperature be too high the lubricant will be squeezed out unless the bearing pressure is low.*

If, referring to Stribeck's and Heimann's curves—Figs. 96 and 97—we take it that the conditions attending the minimum values of the coefficient of friction are those under which the oil begins to escape from the bearing, and that for any lower speed the bearing will run dry, we may find the connection between rubbing speed and temperature on the one hand, and rubbing speed and pressure on the other, which specifies the condition of safe running with a complete oil film.

According to Heimann's curves — Fig. 97 — from experiments in which the temperature of the bearing was varied, whilst the bearing pressure remained the same, it appears that the coefficient of friction attains a minimum for a different value of the surface speed for

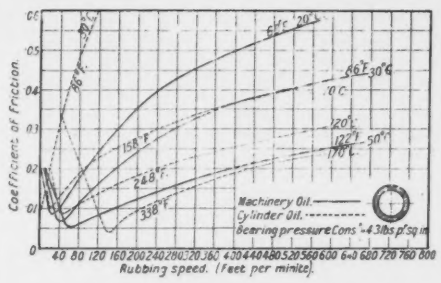

Coefficient of Friction.
66° F 20° C
158° F 70° C
248° F 120° C
338° F 170° C
Machinery Oil.
Cylinder Oil.
Bearing pressure Cons' = 4·3 lbs. p' sq. in.
Rubbing speed. (Feet per minite).

Fig. 97

each different temperature, and that the value of this speed increases proportionally to the temperature, as numerically stated on the Fahrenheit scale. In fact, if v_o be the value of the speed for the minimum, and t the bearing's temperature, Fahrenheit, we find:

$$v_o = \frac{1}{2} t.$$

From Stribeck's and Heimann's curves—Fig. 96—drawn for experiments in which the bearing pressure was varied, the temperature remaining unaltered, the speed for the minimum coefficient is found again to be proportional to the pressure. For Stribeck's Sellers bearing

$$v_o = \frac{1}{2} p, \text{ and for Heimann's — solid — bush bearing}$$

$$v_o = \frac{1}{16} p.$$

Thus v_o varies as t when p is constant, and v_o varies as p when t is constant; therefore, when both p and t vary, v_o will vary as their product; or $v_o = A \, p \, t$.

The value of A in this expression is found to be different not only as between Stribeck and Heimann, but also as between Heimann's constant temperature and his constant pressure experiments.

For Stribeck's Sellers bearing we get

$$v_o = p \, t/35 \text{ (constant temperature).}$$

For Heimann's bush bearing, we get

(a) For constant pressure experiments $v_o = p \, t/82$

(b) For constant temperature experiments $v_o = p \, t/190$ to 240.

Now Sommerfeld has deduced mathematically an expression for this very speed for the minimum coefficient of friction, in terms of the bearing pressure, p; the radius of the journal, r; the difference between the radii of bearing and journal, δ; and the coefficient of viscosity, k.

It is of the form

$$v_o = K \, \frac{\delta^2}{r^2} \, \frac{p}{k} \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

We also found above that the coefficient of viscosity for machinery oil is, for temperatures between 68 deg. Fah. and 160 deg. Fah., well represented by the expression $k = 1/(t° - 60°)$ or $k = 1/\theta^2$ (units = pounds, feet, and deg. Fah).

Substituting this for k in (18) we obtain—

$$v_o = C \, p \, \theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

where C is a constant, *varying as the square of the ratio of the original slackness of fit to the size of the journal.*

We prefer, therefore, to use the formula $v_o = C \, p\theta$, which has a theoretically sound basis, rather than the form $v_o = A \, p \, t$, which can be made to agree with the experimental data of Stribeck and Heimann; more especially as the value of A differs so much for the different sets of curves. We ought, no doubt, to expect to find a difference for this constant, as between the Sellers type of bearing used by Stribeck and the bush bearing of Heimann, but the large variation of A in the two sets of (pressure and temperature) curves given by Heimann for the same type of bush bearing seem to point to some discrepancy, such as a considerable difference in the original amount of slackness allowed between journal and brass in the two runs.

We shall, therefore, use for our purposes in designing bearings the expression $v_o = C \, p \, \theta$, with $C = \frac{1}{80}$ for the value of the constant; and when written in the form

$$\theta_c = 80 \, v_o / p \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

we see that *it gives the critical value (θ_c) of the rise of temperature, above which, under the given conditions as to surface speed (v_o feet per minute), and bearing pressure (p lb. per square inch), the oil will be in danger of leaving the bearing and allowing it to run with metallic contact of the rubbing surfaces.*

* No. XXIV. appeared November 23rd.

THE STRENGTH OF COIL SPRINGS.

By H. E. Wimperis.

About a year ago the author published* some notes on "The Strength of Laminated Springs" with the object of bringing into greater harmony the theory and the practice of the art of spring design. The present article has a similar purpose; in it an endeavour will be made to determine the fundamental conditions and more important formulæ which govern the design of coiled springs. In the pursuit of this intention it will be desirable to consider separately the three chief factors which govern the shapes of springs, viz., (a) the weight of metal which the spring must contain in order that the stressing may not exceed a predetermined limit; (b) the shape, cylindrical or conical, in which the coil is wound; and (c) the cross section of the material. These three factors are capable, to a considerable degree, of being treated independently of each other, although, as it will be shown in what follows, they are really linked together. Taking them in the order in which they are set down, the first factor to be discussed is the weight of metal to be used in the spring in order that it may be capable of storing the required number of inch-tons of energy without the specified maximum stress being exceeded.

The property of material to store per unit volume a considerable amount of energy is the "springiness" of the material, and is commonly called its "resilience;" when so defined the resilience is measured by the number of inch-tons stored per cubic inch (or per lb. weight) of metal, a figure which varies very greatly with different materials, but is highest in the steels and bronzes from which springs are commonly made. In engineering work on any scale—such as railway work—the material used is almost always steel, and that being so, we will consider steel more particularly, although the same treatment will apply equally well to all other elastic materials, if appropriate constants are used. Coil springs act mainly by torsion, but bending effects usually occur also, although to a much slighter extent; inasmuch as torsion is a shearing stress effect, and bending a tensile stress effect, it will be understood that the combination of the two tends to complicate the problem. It happens, however, that the figure for the resilience is far higher for shear than for tensile stresses, and in general only the former need be taken into account. As an illustration of this the case of a steel bar will be taken—first, when loaded directly in tension; secondly, when subjected to uniform bending; and thirdly, when coiled into a cylindrical spring and loaded in the usual manner.

Resilience, or energy stored per unit volume, is easily calculated in cases of direct uniform tension. Taking Young's Modulus as E, the maximum stress as f, and the maximum strain as $\frac{\delta \, l}{l}$, it follows that—

$$f = E \times \frac{\delta \, l}{l};$$

therefore, work done per unit volume

$$= \frac{1}{2} E \cdot \frac{\delta \, l}{l} \cdot \delta \, l \div l = \frac{1}{2} \frac{f^2}{E}.$$

If E be taken as 30,000,000 lb. per square inch, which appears to be its value for ordinary spring steel—though the writer is aware that very various figures have been obtained or assumed in the past—and the maximum safe stress in tension as 60 tons per square inch, it follows that the resilience equals

$$\frac{1}{2} \times \frac{60 \times 60 \times 2240}{30{,}000{,}000} = 0{\cdot}1344 \text{ inch-tons per cubic inch.}$$

For uniform bending it can be shown that the resilience equals $\frac{f^2}{6 \, E}$ when the beam is of rectangular section and is loaded perpendicularly to one of its sides. The value of f in this expression is the maximum stress in tension and in compression; taking the former as "the weaker link" and putting it at 60 tons per square inch as before, the resilience = 0·045 inch-tons per cubic inch, a figure much below that obtained for direct uniform tension, although springs that store energy by bending have the advantage of much greater flexibility and are often used, whilst the uniform tension spring is practically unknown. The "bend" spring could, however, be made to have its resilience raised to that of the "direct stress" spring were it made from a hollow bar which had very thin sides and relatively thin top and bottom, as in that case the stresses would be very nearly uniform in the greater part of the mass.

The consideration of springs that act by torsion is complicated by the very intricate relation which subsists between loading and deflection whenever the section of the material is not circular. As the circular section is so much simpler, it will be considered before the square and rectangular sections, but first it will be necessary to take the case of a simple uniform shear, such as that experienced by a square block of india-rubber when two of its parallel surfaces are caused to slide parallel to themselves in opposite directions. For such

* See The Engineer for September 15th, 1905.

a stress the resilience $= \frac{f^2}{2N}$, where f is the maximum shearing force and N is the modulus of rigidity; then taking f as 70 tons per square inch and N as 12,600,000 lb. per square inch, the resilience = 0·436 inch-tons per cubic inch. In the case of stresses in torsion, where the section is circular and the stress varies from zero inside at the centre to a maximum at the circumference, the resilience is exactly half this, being $= \frac{f^2}{4N}$, which, with the above constants, = 0·218 inch-tons per cubic inch. It is this figure that applies to the case of coil springs of circular cross section and cylindrical build, since, as is well known, coil springs deflect in virtue of the twisting of the material. When springs are coiled out of material of rectangular or square section the problem becomes far more complicated mathematically, but the investigations of the mathematician St. Venant may be utilised to obtain practical results. From the work of this mathematician, as condensed by Mr. A. E. Young,* the following figures may be calculated:—

Resilience $= a\frac{f^2}{N}$, where a is as given below for each section of material.

Ratio of sides of rectangle.	a.
1	0·153
2	0·132
3	0·135
4	0·142
5	0·145
6	0·149
10	0·156
20	0·161
100	0·165
Infinite	0·167
Circular section	0·250

It will be seen from the above that the multiplier a varies little even when the ratio of the sides changes greatly; in fact, it would introduce no serious error, and would greatly simplify matters to write down a as 0·145 for all rectangular sections that are likely to be used. This would give the resilience for rectangular springs as 0·126 inch-tons per cubic inch. Or, if the resilience be preferred expressed per pound of metal in the spring instead of per cubic inch, the transformation may be made by writing the weight of a cubic inch of steel as 0·30 lb. This would give the resilience for circular sections as 0·73 inch-tons per pound, and for rectangular sections as about 0·42 inch-tons per pound. These figures represent the extreme amounts of energy that could be stored in the springs, as 70 tons per square inch is very near the breaking point, and it would, of course, be advisable to leave some margin for safety's sake, the amount of the margin depending upon the purpose and shape of the spring. In making any such calculations it is very necessary to remember that to lower the highest permissive stress by 1 per cent. is to lower the energy stored by 2 per cent.

So much for the considerations affecting the weight of springs. It next remains to settle their shape, and this must depend upon the degree of stiffness required and upon the maximum stress which can be permitted when the spring is in the scragged position. It is necessary, therefore, to state the formulæ governing the change of shape of the spring when external forces come into play. Consider the case of a cylindrical coil spring, and let the following notation be used:—

r = radius of cylinder measured to the centre of the section.
l = total length of coiled spring when unwound.
w = axial load tending to compress the spring.
L = couple—if any—trying to wind up the spring.
α = angle of slope of helix.
x = axial deflection.
ϕ = angle of winding up.
A = angle of twist per unit length of material when unit twisting moment is applied.
B = angle of bend per unit length of material when unit bending moment is applied.

Then it can be shown—it would add unduly to the length of this article to give the analysis in full—that

$$x = l\left\{ w r^2 (A\cos^2\alpha + B\sin^2\alpha) + L r \sin\alpha\cdot\cos\alpha\,(B - A)\right\} \quad \ldots\ (1)$$

and

$$\phi = l\left\{ L\,(A\sin^2\alpha + B\cos^2\alpha) + w r \sin\alpha\cdot\cos\alpha\,(B - A)\right\} \quad \ldots\ (2).$$

This applies to a cylindrical coil spring, but if it be desired to consider the case of conical springs, such as buffer springs, in which the coils can slide one inside the other, thus making the scragged height merely the height of the strip used in winding, all that is necessary is that r should be interpreted as the mean radius of all the coils, and, this being done, formula (2) applies exactly as before, and formula (1) remains correct to a close degree of approximation.

The cylindrical type of spring is the most common, and it is therefore selected as the type of spring to be treated at most length. The formulæ above given contain a variable L, which is the applied couple tending to twist up the spring. In most practical cases no attempt is made to bring into play any such couple; but as the spring on being compressed always has some tendency to rotate on its axis—so slightly altering the number of coils—since even if L = O, formula 2 gives $\phi = w\ l\ r\ \sin\alpha\cdot\cos\alpha\ (B - A)$, so that, except in the single case when A = B, ϕ will have some value or other. As, however, the effect of the end plates is to introduce a frictional couple, this may restrain the rotation wholly or partly from taking place. If rotation of this kind is prevented by such forces, ϕ becomes zero, and therefore—

$$\phi = o = l\left\{ L\,(A\sin^2\alpha + B\cos^2\alpha) + w r \sin\alpha\cdot\cos\alpha\,(B - A)\right\}$$

$$\therefore L = -\frac{w r \sin\alpha\cdot\cos\alpha\,(B - A)}{A\sin^2\alpha + B\cos^2\alpha} \quad \ldots\ (3)$$

and this shows the amount of the frictional couple preventing the rotation. Now this couple must have an effect upon the deflection, since the two are interrelated. The amount of such effect can be obtained thus:—

From equation (1) $x = l\left\{ w r^2 (A\cos^2\alpha + B\sin^2\alpha) + L r \sin\alpha\cdot\cos\alpha\,(B - A)\right\}$

Now substitute for L, as in equation (3);

Therefore $$x = w l r^2 \frac{A\,B}{A\sin^2\alpha + B\cos^2\alpha} \quad \ldots\ (4)$$

and it consequently follows that x must always lie between this value and that given by putting L = O in equation (1) viz.—

$$x = w l r^2 (A\cos^2\alpha + B\sin^2\alpha). \quad \ldots\ (5)$$

Incidentally it will be observed that for very small values of α these two equations tend to become equal to each other, and to

$$x = w l r^2 A. \quad \ldots\ (6)$$

It is an interesting point to discover how nearly these two equations (4) and (5) approximate when α is not extremely small. In this case it can be shown that the ratio of x, with rotation restrained, to x, with rotation unrestrained

$$= 1 - \frac{(A - B)^2}{A\cdot B}\cdot\sin^2\alpha \text{ nearly.} \quad \ldots\ (7)$$

This expression has been evaluated for a spring of circular cross section, and with an angle of slope of helix as high as 30 deg., and even then the ratio is only less than unity by 1¼ per cent., being 0·9875, so that the end friction can have but little effect upon the flexibility of the spring. It happens in most cases that a considerable fraction of the material of a coil spring is of use merely as a guide or framework to the rest, and in itself does no useful "spring" work—thus in an ordinary cylindrical spring the top and bottom coils are in contact with flat surfaces, and therefore suffer no distortion or straining on the spring being deflected; they are, in fact, only guides which receive the load and transmit it as a continuous pressure over the area in contact, and permitting as a resultant a force which acts along the axis of the spring. If, therefore, the weight of such a spring be divided into the number of inch-tons stored, the resulting figure representing the resilience will be a figure which is merely an average for the whole spring, and as certain parts, the ends, to wit, are unstrained, it is clear that the central part of the spring must be storing per pound a larger amount of energy than such a figure would indicate. At first sight it might, therefore, seem requisite to deduct the weights of the top and bottom coils by deducting two coils from the total number and reducing the weight accordingly; this, however, would not be accurate unless the number of coil is counted "tip to tip," since the top and bottom coils are almost always tapered off in thickness, and weigh together probably no more than one complete coil of sustained section. In finding, therefore, the inch-tons per pound stored in the material of a spring (with a view to divining whether the steel is suitably stressed) it is necessary to divide the inch-tons by the weight of the spring, less one complete coil.

It yet remains to discuss the best section to employ for any desired spring. From the figures given in the early part of this article it is clear that a square section is not so advantageous as a circular one, seeing that the maximum inch-tons per pound storable in a circular section is 0·73, against 0·42 in the case of the square or rectangular sections. The ratio of these two figures to each other is about 0·6, and as this is less than the ratio of the area of a circle to an escribed square, it is clear that a square-sectioned spring would be strengthened by having its angles cut away till it came to a circular form, and this not only as a relative benefit, but as an absolute one, as not only would the new spring be stronger per pound—as all circular-sectioned springs would be—but it would actually be able to store a greater number of inch-tons of energy for the same maximum stress. So it follows that any square-sectioned spring is less capable of storing energy than one of a circular section which could be contained inside it. This is strong theoretical testimony to the disadvantages of sharp corners on springs. The whole of this argument is based upon the existence of the same upper limit for the safe stressing of the steel. Actual fracture, of course, is often determined by complicated factors, of which the amount of plastic yielding, as suggested in the author's earlier paper, is one.

Having regard to the infinite number of sections that can be rolled, it is impossible for mathematical calculation to follow out each individual case, and it is therefore not advisable to make *ex cathedra* statements upon the subject. The only reply to be made to the question, What really is the best section to use? is, Practical tests made under working conditions are the only sure guide in design when "fancy" sections are concerned. As regards the simpler sections, theory gives the palm to the circular section, and it adds the advice that the claims of other sections to improve upon it should be very closely scrutinised. It must be remembered that in all such problems springs are assumed to be formed of a material homogeneous in structure, but if sharp corners or rounded projections are left on, these will tend to cool more rapidly in the hardening and tempering processes, and so yield a steel of unequal temper; this will, of course, affect the strength of the spring, and it is not easy to imagine any case in which it would be beneficial.

The relation between the maximum stress and the shape of the spring can be obtained through the resilience relationship, and so obtained most simply; sometimes, however, it may be desired to calculate the stress from the deflection, and in that case the following method should be employed. Take first a cylindrical spring of the simple circular section; the angle of twist on the material $= x/r$, and the twist per unit length $= x/r.\,l$. Therefore, the strain at the circumference = D. x / 2 r. l, and the stress corresponding to this is clearly

$$D.\ x.\ N / 2 r.\ l \quad \ldots\ (8)$$

For other sections, such as the rectangular, the work of St. Venant—most conveniently as condensed by Mr. A. E. Young—has to be used, and from them it follows that the maximum stress = C. N. $s.\ \theta$, where s is the length of the shortest side of the rectangle, θ is the angle of torsion per inch, and where C is a constant which for a square is 0·675, and for any rectangle of which the longest side is three or more times the shortest becomes practically unity, in which case the formula reduces to f = N. $s.\ \theta$. The better way is, however, to proceed by means of the resilience relationship.

The useful formulæ for the design of the simpler spring sections are those already given under the numbers (1), and (6), and as an illustration of their working the following instance may be given:—

Example: It is required to design a cylindrical spring of circular cross section so that it shall deflect 2in. with a load of five tons, and enable a rod of 2¾in. diameter to pass through the middle of the coil.

Working.—The energy to be stored is to be 5 inch-tons. The inch-tons storable per cubic inch with a maximum stress of 70 tons per square inch is 0·73, and if it be not desired to exceed a maximum safe stress of 60 tons per square inch, then the inch-tons storeable per cubic inch = 0·73 × (60/70)² = 0·53, and therefore the weight of steel required to be put into the spring = 5 ÷ 0·53 = 9·4 lb.

Again, from equation (6), $x = w\,l\,r^2\,A$, and $A = \frac{32}{\pi N D^4}$ in the case of a circle.

$$\therefore 2 = 5 \times l r^2 \times \frac{32}{\pi D^4 \times 5640}, \text{ which gives } \frac{l r^2}{\pi D^4} = 70{\cdot}8.$$

Now, if the internal diameter be 2⅞in.—so as to allow the central rod 1/16in. clearance a side—then, $2\frac{7}{8} + D = 2r$,

$$\therefore r = \tfrac{1}{2} D + 1{\cdot}4375.$$

Again, in 9·4 lb. there are $\frac{9{\cdot}4}{0{\cdot}3} = 31{\cdot}3$ cubic inches of steel;

$$\therefore l \times \frac{\pi}{4} D^2 = 31{\cdot}3; \quad \therefore l = \frac{125{\cdot}2}{\pi D^2}.$$

Substitute for l and r in $\frac{l r^2}{\pi D^4} = 70{\cdot}8$;

$$\therefore \frac{125{\cdot}2}{\pi D^2} \times (\tfrac{1}{2} D + 1{\cdot}4375)^2 = 70{\cdot}8\,\pi D^4;$$

$$\therefore 125{\cdot}2\ (\tfrac{1}{2} D + 1{\cdot}4375)^2 = 70{\cdot}8\,\pi^2 D^6 = 700\ D^6;$$

$$\therefore \tfrac{1}{2} D + 1{\cdot}4375 = 2{\cdot}37\ D^3.$$

The nearest even fraction for D to satisfy this cubic equation is easily found to be 1⅝in.; $\therefore r = \frac{1}{2}$ (0·9375) + 1·4375 = 1·90in., and $l = \frac{125{\cdot}2}{\pi D^2} = 45{\cdot}4$in. Length of one coil = 2 πr = 11·9; ∴ number of active coils = 4, and, allowing for the end partial coils, the total number of full coils = 5, or, if the coils be counted "tip to tip," six coils. This gives the shape of the spring. This result can be refined by calculating the free height (5 × 1⅝in. + 2in.), and so finding α (in this case it is 8½ deg.), and then calculating out x carefully from equation (1). This process of continued refinement can be carried out to any degree of accuracy desired.

PRAIRIE TYPE COMPOUND ENGINES AT MILAN EXHIBITION.

THE "Prairie" type—or 2-6-2—locomotive, promises to be admitted into the regular practice of the Continent, as it is also in America, but to a more restricted extent, for while in the United States the driving-wheels may carry loads of 170,000 lb., in Europe the existing limits of from 105,000 lb. to 118,000 lb. would necessitate another wheel arrangement, or, in other words, another wheel type for very heavy locomotives. The main object of the "Prairie" type is to concentrate the greatest possible weight upon the driving-wheels, the total number of wheels being limited to ten. Examples of this type are in regular service in Austria and Italy, and it is precisely in these countries that the wheel loads are least—never exceeding 95,700 lb. for the three axles. Mr. Goelsdorf, of the Austrian State Railways, was the first to introduce this type—January, 1905—for working express trains on continental railways. Although it is an economical design with only one pair of leading wheels, it does not fulfil every condition necessary for fast passenger services, and one noted locomotive builder of the Continent—Maffei—has now passed over this type in introducing yet another American type—the "Pacific"—in which the leading four-wheel bogie is retained, and a wheel arrangement of 4–6–2 obtained.

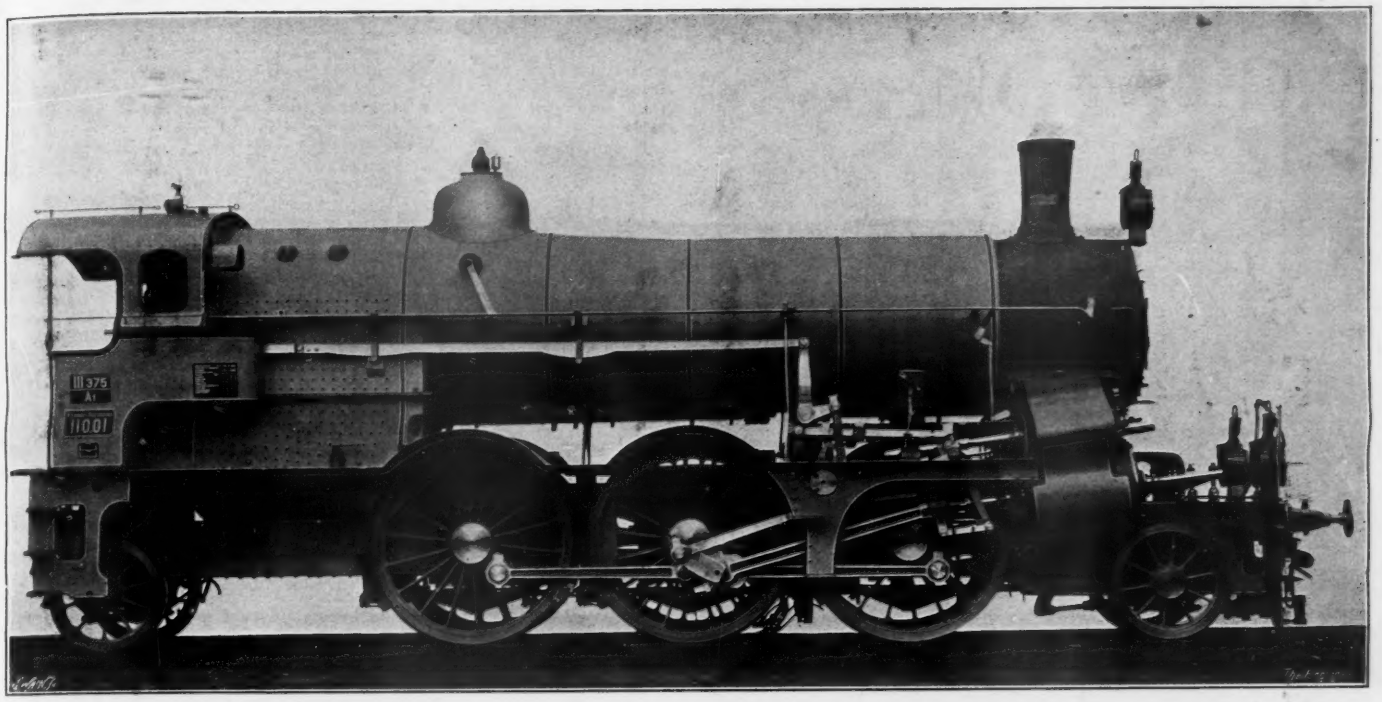
In service on the Austrian railways the four-cylinder compound "Prairie" type engine of Mr. Goelsdorf can pull trains of 400 tons up gradients of 1 in 100 at the rate of 34 miles per hour, and in trials has run at all speeds up to 74 miles per hour with remarkable smoothness. It is intended for the heaviest of Austrian trains, and for all grades up to 1 in 50. This engine was exhibited at Milan, and is illustrated on the next page.

The arrangement of the engine is of the usual Central European type, with all cylinders in line, and all connecting-rods working upon one pair of driving wheels. All the cylinders are placed at an inclination of 1 in 8. This is necessary so that the inside crossheads may clear the leading coupled axles. The outside cylinders are placed at the same angle, in order to simplify construction. The cylinder castings are in one piece for each pair of high-pressure and low-pressure cylinders, the two castings being bolted together in the centre line of the engine, with the low-pressure cylinders outside as usual.

* See "Proceedings," Institution of Civil Engineers, 1890.

COMPOUND LOCOMOTIVE, AUSTRIAN STATE RAILWAYS

WIENER LOKOMOTIV-FABRIKS, FLORISDORF, ENGINEERS



There are, of course, only two valve mechanisms for the four cylinders.

The valve gear is the normal Heusinger—or, as we call it, Walschaert's—arrangement for slide valves, and therefore as the rocking transmission from the outside to the inside valves must necessarily cause the inside valves also to admit steam by their outside edges, a special arrangement of reversing rocker is employed, this being common, with but slight differences, to all the four-cylinder engines of the Austrian State Railways. There is no intercepting valve, as the engines always work compound, but in the seatings of the low-pressure valve chests there are orifices—Goelsdorf's patent—which permit live steam to enter the low-pressure valve chests automatically whenever the reversing gear is set forward in the usual starting positions. For the realisation of the fullest advantages in compounding, at moderate piston speeds, the ratio adopted here for the cylinder volumes, high-pressure to low-pressure, is 1 : 2·93. The same proportion is maintained for new goods engines using superheated steam and higher steam pressures.

The crank axle is of the oblique type, with all journals and crank pins bored out hollow. The material employed is special crank steel from the Neuberg works of the Alpine Montan-Gesellschaft. The straight axles are of Martin steel, containing 1 per cent. of nickel, obtained from the Ternitz works of Schoeller and Co. The wheel centres are steel castings—Martin process—from the steel works of Witkowitz, and the crucible cast steel tires are from the Ternitz works. The boiler plates and frame plates of Martin mild steel are from the Zeltweg Works of the Alpine Montan A.G. The tubes also are of mild steel—*flusseisen*—from the Komotauworks of the Mannesmann Rohrenwerke, and the copper sheets for the fire-box are from the Kamenitz works of Franz Ringhoffer.

The engine is fitted with two Friedmann oil pumps, lubricating all pistons, slide valves, and the rear packings of the high-pressure pistons inside the frames; two suction injectors of Friedmann's model S.T.; the Rihosek steam sanding apparatus; Marek's smoke-consuming and coal-economising air register in the fire-door; Hausshaelter's speed indicator and recorder; steam train heating apparatus with Foster's reducing valve, and the vacuum rapid-acting (1902) brake operating upon all the driving-wheels, but not on the bearing wheels, which in this engine have radial axle-boxes of Adams' type.

The engine was built by the Wiener Lokomotiv-Fabriks at Florisdorf, and is finished in a style which can only be termed severely mechanical. It is classed "Series 110."

The following are the leading dimensions and particulars:—

Cylinders, high-pressure, two	14½in.
,, low-pressure, two	24½in.
,, piston stroke	28½in.
Driving wheels, diameter	71⅝in.
Boiler pressure	220½ lb.
Heating surfaces, fire-box	147·4 sq. ft.
,, ,, tubes (No. 282)	2625 sq. ft.
,, ,, total...	2772·4 sq. ft.
Tubes, length	17ft. 3in.
,, diameter, inside and outside	1¾in. and 2⅛in.
Grate area...	43 sq. ft.
Bearing wheels, diameter	40⅜in.
Rigid wheel base	3·900 m.
Total wheel base	9·490 m.
Adhesion weight, maximum	42·9 metric tons
Engine weight, empty	61·8 ,, ,,
,, ,, fully loaded...	68·9 ,, ,,

The tender is carried on six wheels. It is suited to the special order of service for which the engine is designed, and weighs empty only 14 tons. It carries 3685 gallons of water and 8½ tons of coal, and fully loaded weighs 39 tons. It has the improved trough-fillers projecting from each side of the tender and extending the whole length of the sides.

THE FEDERATED MALAY STATES.

THE recently issued annual reports of the Resident-General, and the several Residents of the Federated Malay States, contain a mass of useful, interesting, and highly satisfactory information regarding the development of British government and influence in the regions of the Far East. Substantially, these reports continue the record of progress and prosperity, which has characterised in the past the pages of similar official communications. This Federation embraces the four protected native States of Perak, Selangor, Negri Sembilan, and Pahang, which previously to their incorporation under one title, formed distinct but contiguous settlements. It will be seen after a very brief consideration of the subject that the great advance during last year in almost every item of variable value has been in the States of both a collective as well as of an individual nature. Viewing them in the former light, the revenue raised in the Federated States in 1905 amounted to 23,964,593 dols., which is a million and a-third in excess of that for 1903, hitherto the highest on record. The receipts from Customs, rubber, land revenue, licences, and railways, all show an increase as compared with the receipts of the previous year. Those of the railway department reached a total of over four millions, surpassing by the large sum of 369,513 dols. the last annual returns. On the other hand, the same department must be debited with a relative expenditure of a million and a-half more dollars. The trade of the States during the year 1905 is described as not merely satisfactory, but very prosperous, the aggregate recorded value amounting to 130 millions. A marked increase took place in both imports and exports, especially under the head of "Raw Materials," which comprise the articles on which the prosperity of the States mainly depends. These are tin, tin ore, Para rubber, and manufactured metals, chiefly wolfram. It is a common saying in the Malay Peninsula that wherever you stamp your foot, there is tin underneath.

The principal engineering and constructive undertakings carried out by the Public Works Department will be described when reference is made to the separate States, but the railways are deserving of a general statement. There were, at the end of 1905, 396 miles open for traffic, including the increase during the year of 56 miles, together with some 50 miles of sidings and minor branches. At the close of the year the receipts showed a net profit of 4·46 per cent. on the capital account, and the percentage of working expenses to gross profits was as 57·80 compared with 59·09. The total constructive works cost 4½ million dollars, in which sum is included 3½ for the expenditure incurred in the building, and in the surveys of new lines, in the States, and in Malacca and Johore. It should be noted that the high price of rubber, and the proved suitability of the land for its cultivation, have led to numerous applications for large areas in all four States, and most of the large estates have been converted into, or sold to limited liability companies. The total population of the Federated States is estimated at not less than 860,000.

The State of Perak, the name of which signifies "silver" in the Malayan vernacular, is the largest and most populous of the four. Its revenue for 1905 exceeded that of the previous year by 910,000 dols. The general farms have been re-let for a further term of three years at an increased rental of 50,000 dols. a month, which is the highest bid that has ever been received. The Chinese residents, whose forecast in this direction is usually very accurate, regard the circumstance as an indubitable presage of the future prosperity of the State. As it is, the balance-sheet of assets and liabilities shows a credit surplus of eleven and a-quarter millions, or two millions more than the corresponding figures for 1904.

The Malacca railway has been purchased at cost price by the Federation, and in Perak the construction of the Tronoh line, and the connection of Tapah with the main track, have been put in hand. Two and a-third millions were expended on public works, comprising among minor examples a central school at the capital, Taiping, a revenue survey office, an extension of the principal jail, new Courts of Justice, and a residence for the High Commission; water supplies, drainage works, and road-making have been strongly in evidence throughout the greater part of the State, and a quarter of a million has been spent on the Krian irrigation. There are at present 570 miles of metalled roadway in the State, maintained in excellent condition for all kinds of traffic. Notwithstanding that 325 miles of traverse surveys were run for various purposes, and that the survey of Kinta, which includes an area of 150,000 acres, was revised, it is stated that "it is not until one studies the detailed returns of the revenue surveys in Perak that one is able to realise how understaffed the department is, or how great is the demand for land in the State. During the year applications for 31,000 acres were received, and at the termination of it, the total number of unsatisfied applications covered an area of 50,000 acres. Such a state of affairs calls for early rectification." It is not an instance of want of money, for over 100,000 dols. are lying idle in the Treasury, "for surveys which have not been undertaken, and it behoves the Government to make an earnest endeavour to overtake the work." A very similar condition of affairs prevails in the Road Department, for it is remarked that "it is expedient to strengthen the staff by appointing assistant engineers to take special charge of roads." Since this partial depletion of the engineering and surveying departments is common to three out of the four States, it will be well worth the while of some of the younger members of the profession seriously to turn their attention to it.

The State of Selangor, which comes second on our list, is the most centrally situated of those included in the Federation. At the beginning of 1905 the balance of assets over liabilities stood at 13½ million dollars, which at the end of the year had increased to 15 millions. There was a substantial advance in inland revenue, not only over that of 1904, but over the figures of all previous years. It is significant as an item indicating the permanent prosperity of the State, that the rents collected in respect of town and agricultural land were twice the amount of those accruing to the treasury from mining land. Owing to the rapid development which has attended the cultivation of Para rubber, and the excellent results which have been obtained, it is being planted in every district of the State, especially in the coast districts of Klang and Kuala Selangor.

Among the principal public works may be mentioned the new museum, which is now practically completed; the new post-office buildings at Kuala Lumpur, the capital, and the installation of the electric light at the same place. The improvement of the approaches to Port Swettenham has been commenced by the erection of four screw pile beacons, at a cost of 21,000 dols., and the construction of a tower 90ft. in height, carrying an occulting light. There are 789 miles of streets, roads,

POWER STATION AT WANGEN

Fig. 1—FLOOD GATES

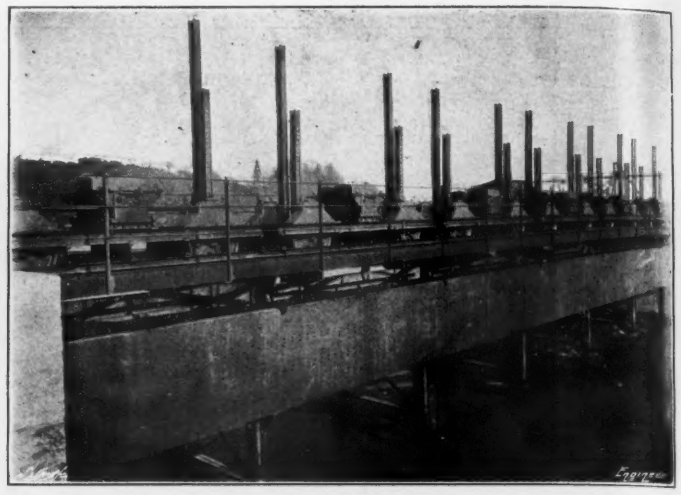


Fig. 2—INTAKE SLUICES

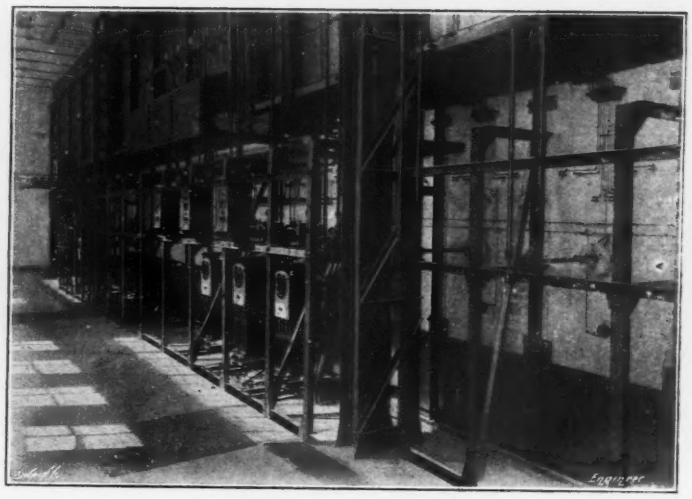


Fig. 3—BACK OF SWITCHBOARD

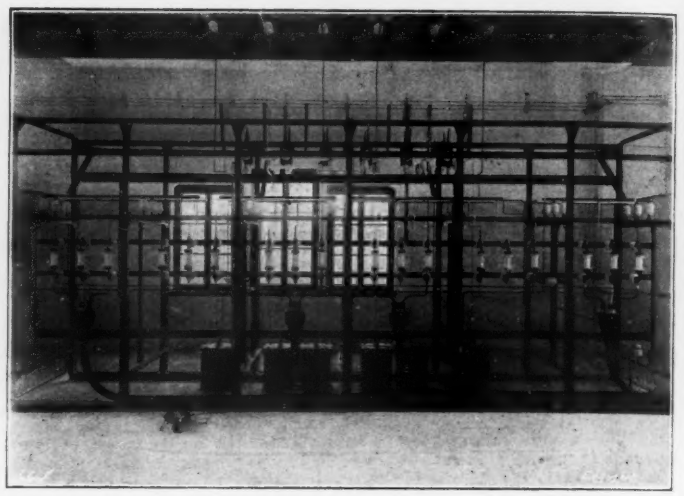


Fig. 4—HIGH-TENSION SWITCHES

and paths in Selangor, maintained at an annual cost of half a million. Operations in road construction include a new route, twelve miles long, to the boundary of the neighbouring State, Pahang, a branch road four miles in length, and several extensions and improvements of existing thoroughfares. Bridge building has been very active. A 75ft. span of the bowstring type has been thrown across the river Chilling, and one of 54ft. over another river. In addition, some forty iron structures, varying in span, have replaced the old wooden bridges of earlier days. New waterworks are urgently needed for the supply of the capital, and three alternative schemes have been submitted to the Director of Public Works, whose final selection is anxiously awaited,

Negri Sembilan is a comparatively minor State with a population of 120,000, but has followed in the footsteps of her larger and more powerful friends. The chief feature of the year in matters agricultural has been the conversion of practically every private estate into a limited liability company, having for its object the cultivation of Para rubber, which has retained its high price throughout the year. For reasons already assigned, there is nothing worth recording respecting the operations of the survey department. Beyond a traverse of the Sungie Ujong Company's line, 29 miles in length, no work was done in the State by the trigonometrical survey branch during the past year. Mention may be made of two roads now under construction, the more important being the new Pahang road, which for 37½ miles is in Negri Sembilan territory, and will be open to traffic by the end of 1907. The other route is 15 miles long, and is nearly finished. It provides access to the Batu Bersamah gold mine, and the lands in that district. The building of a new residency, of public offices, and the prosecution of the Seramtan waterworks, complete the list of public works of any magnitude.

While the State of Pahang, the smallest in the federation, is credited with increases in most of the items composing the revenue, its expenditure exceeded that of 1904 by some 300,000 dols. Under the heads of roads, streets, and bridges, will be found the principal items contributing to this increase. In the survey department preparations were commenced for the major triangulation for the proposed preliminary map, upon a scale of 4in. to the mile, and several station points were located in favourable positions. Surveys for the establishment of future roads were undertaken over 250 miles of country hitherto unexplored, and an additional 30 miles of trace were made by European and Australian surveyors. Pahang is situated on the east coast, to the south of the Gulf of Siam, opening into the China Sea, and the question of the improvement of Kuantan Harbour has been for some time under consideration. In November last Mr. W. Matthews, C.M.G., of Messrs. Coode, Son and Matthews, visited the locality with a view to advising as to the most suitable measures to be adopted towards attaining the object in view. His report is now awaited. Pahang has still some leeway to make good, as she is in debt to her two sister States, Selangor and Perak. The total loan account at the end of the year amounted to five million dollars. It seems clear that the obligation is not of a very pressing nature, since the money is granted free of interest. The future value and importance of the Federated Malay States is assured. They will form the connecting link between Singapore, our "halfway house" to the "Far East," and the countries of Burma, India, China, and Thibet.

HYDRO-ELECTRIC POWER STATION AT WANGEN.

One of the newest and most important high-tension hydro-electric installations, erected along the course of the river Aare, is that situated at Wangen, in the Canton of Berne. From the results of several tests made as to the quantities of water available in the Aare at different seasons of the year, the minimum volume at disposal has been found to be about 75 cubic metres per second. As, by official regulations, 6·5 cubic metres per second must always be left to flow in the bed of the Aare, there are thus at least 68·5 cubic metres per second always left at disposal even when the water is at its lowest. The maximum flow which has been noted is 1464 cubic metres per second, but the average flow is fairly uniform. It is estimated that a minimum water level of 2·99 m. exists for about three-quarters of the year, which corresponds to an available quantity of water of about 100 cubic metres per second, consequently the sectional area of the canal for the turbine plant had to be adapted to a flow of 100 cubic metres per second with a normal water level. With a water level of 2·99 m. the full head of the Aare amounts to 422·15 m. — 411·35 m. = 10·80 m. In the concession the maximum water level at the weir is given at 421·53 m.; with a full flow, however, the level may be as much as 423·25 m. With a normal head of water altogether 1·27 m. in head is lost in the canal and in the canal inlet, so that—under normal conditions—a water level of 420·26 m. may be reckoned upon at the turbine house At flood levels, however, the surface of the upper level may be kept at 420·66, and in that case the canal will have to carry as much as 120 cubic metres per second.

The effective power of the turbines is estimated at 9000 horse-power. At the point where the barrage has been placed the Aare has a breadth of 120 m. between the banks. The right bank in the neighbourhood of the weir is provided for 100 m. up and down stream with a stone batter or scarp, upon which the concrete ramp for the weir bridge is mounted. In the vicinity of the weir, and of the intake building, the left bank has been covered with concrete. Between the banks there is the dam, which has been bridged over—see Fig. 6. Immediately above this, and deviating somewhat obliquely from the Aare, is the canal inlet, with two governing sluices arranged in series. Between these a gravel collecting

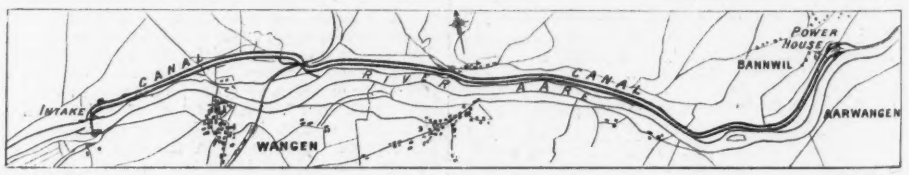


Fig. 5—MAP OF RIVER AARE, NEAR WANGEN

canal describes an arc, and returns to the Aare, into which it again discharges at about 100 m. below the point where the canal branches off. There is the usual provision for allowing of the passage of fish, the arrangement being such as is ordinarily employed in such cases. The weir consists of concrete faced with blocks of granite, the upper edge lying at a level of 419·38 m. On this weir is arranged a series of movable sluices or flood-gates, which can be operated from the weir bridge. The piers of the bridge have two clear openings of 37·24 m. each.

For carrying off flood water there is provided a cross sectional aperture, when the flood gates are drawn up, of 215 square metres at the main weir openings, of 40 square metres through the floating sluices, and of 100 square metres through the spilway. To this must be added 120 square metres free cross sectional area through the gravel collecting canal, so that altogether there is an available effective water outlet area of 475 square metres. The fixed weir consists of a concrete ridge faced with blocks of granite and 1·65 m. high. It rests upon a concrete foundation 1·5 m. thick. The subsoil of the site consists of fine sand, so that the weir had to be constructed upon piles. Above the fixed weir there are, in both of the weir openings, eight sluices, each 4·68 m. in breadth. The foundation of the weir bridge, which is built of wooden beams, is placed at a level of 426·51 m. The fish ladder lies on the left bank, and within the left abutment of the weir. Immediately above the weir the canal inlet branches off on the left bank at an angle of about 70 degrees to the direction of the river. Its breadth is 30 m. The walls of the bank consist of concrete.

The upper canal or head-race is 8·3 kiloms. long from the intake to the turbine house—see Fig. 5—and, for the most part, it has been excavated in soil, though rock is met with in places. The route lies alternately through gravel, sand, and clay. On the straight stretches of the channel, the canal was excavated by means of two electric dredgers, each having a capacity of 1500 cubic metres per diem. For working the dredgers and the other machinery used for building purposes a portable transformer house was used.

The breadth of the bottom of the canal is, as an average, 17 m., and the depth of water is 4 m. when the total amount of water flowing amounts to 100 cubic metres per second. The most difficult point in connection with the construction of the upper reach of the canal was building it beneath the Olten-Solothurn Railway, at which point the river Moosbach effects a junction with the Aare; in addition to this there was also a bridge over a country road. About 200 m. from the turbine house the canal gradually widens out to a breadth of 50 m. Below the works a tail-race 74 m. in length in the central axis was required—see Fig. 7.

The engine-house occupies the entire width of the head-race. It has seven turbine chambers arranged in series; a machine hall with a broadened out central building for the switch-boards, and a four storied tower-like structure on the left canal bank. The building is 67·5 m. long, of which 9·9 m. are occupied by the tower. Apart from the ante-chambers and the tower, which stand on the bank, it rests upon a concrete foundation built across the canal; this foundation is 65·21 m. long and 35 m. broad. As the subsoil consists of a thick and tenacious layer of clay, no piling or other protective means were required. The ante-chambers and turbine chambers are formed by pillars 1830 mm. thick, which get shorter towards the canal dam, whilst up-stream they form the points of support for the stop-planks placed obliquely to the axis of the canal; these stops consist of flat iron bars placed obliquely and supported in the centre. In front of these the bottom of the canal is provided with a concrete covering, which is secured by means of concrete spurs.

From the turbine chambers, which can be shut off from the upper canal by means of sluices, the water passes through the turbines into the discharging chambers, which are hollowed out in the concrete substructure, and which extend below the engine hall to the tail-race. On the left bank of the canal the engine hall is joined to the tower, which measures 9·9 m. by 12·78 m., and the lower storey of which comprises offices, an accumulator room, a store room for oil, &c. The ground floor serves as an ante-chamber for the engine-hall; above the ground floor there are two other stories. For shutting the turbine chambers off from the ante-chambers there are, in each case, two valves or sluices, placed side by side. Sluices for six turbine chambers are already constructed, but only four so far are fitted with turbines.

Each turbine chamber contains two Francis double turbines, with one common shaft and one suction pipe to each. Each pair of turbines produces together 1500 horse-power at a speed of 150 revolutions per minute, with an average head of 8·4 m., and with 17·3 cubic metres of water delivered per second. The two double turbines, which were made by Messrs. Escher, Wyss, are connected to each other by a sheet-iron drum.

On entering the engine hall the turbine shaft rests in a bearing, and, immediately behind it, carries a flexible coupling of the Zodel type, for connection with the shaft of the alternating current generator—see Fig. 11. The turbine shaft lies 5·75 m. above the lowest low-water level, below which the suction pipe extends for 650 mm. Besides these 1500 horse-power sets of turbines there are also two small Girard turbines, each driving an oil pressure pump for the governing motors for the large turbines. The engine-room is 56·76 m. long. The dynamo plant consists at present of four alternating current generators with rotating fields. Their output is 1250 kilowatts, at a pressure of 11,000 volts, and a periodicity of 50 per second at a speed of 150 revolutions per minute. The exciting dynamos, of which one is provided for each alternator, have each an output of 205 kilowatts, with a potential of 110 volts.

The alternating current, at 11,000 volts potential, generated by the large engines is conveyed to the switchboard by cables laid at a depth of 150 mm. in channels—covered with plates of iron—made in the floor of the engine-room. Measuring transformers are connected up in front of the engine switches; these transformers reduce the potential for the voltmeters, and for the synchronising apparatus, &c., from 10,000 to 110. From the switchboard the long-distance leads take their departure, and are connected to the necessary lightning conductors and other protective devices. The current from the exciting dynamos can be sent direct to the field coils, or into common bus bars. For the private use of the works themselves a continuous current transformer plant is provided. The alternating current switch plant is so arranged as to be comprised in two stories in the central building, closed off in front by the switchboard and by a glass partition. The upper storey receives only high potential current of 11,000 volts, the meter rotary current, and the low-tension continuous current, passing into the lower storey.

A lightning arrester is mounted as a shunt to each lead, a separating switch being provided. The six leads are then conducted outwards to the overhead transmission wires by means of downwardly directed porcelain sleeves let into the wall of the tower. The area supplied by the works amounts to 65 kiloms. from south to north, and to 30 kiloms. from east to west. The double overhead wire, designed for a tension of 10,000 volts, is carried along the canal from the works up to the intake building. It then extends from the works for a distance of 12 kiloms., where there is a branch going further to the south and

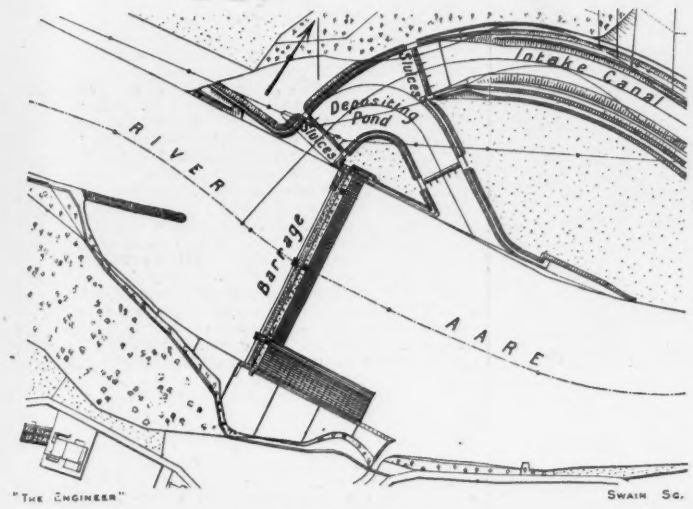


Fig. 6—THE BARRAGE

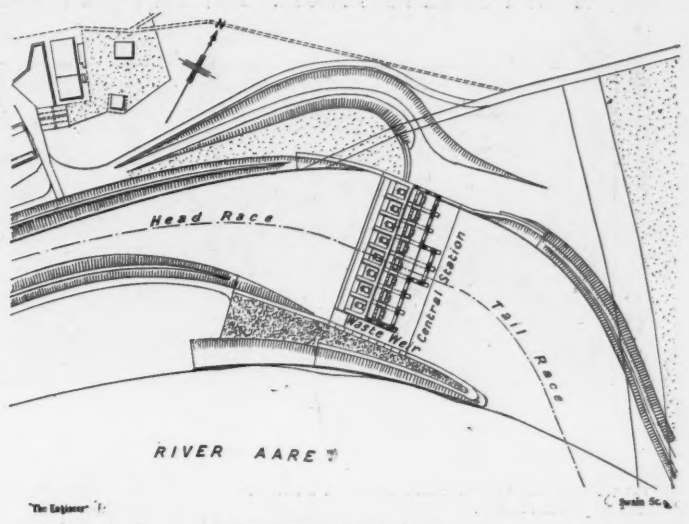
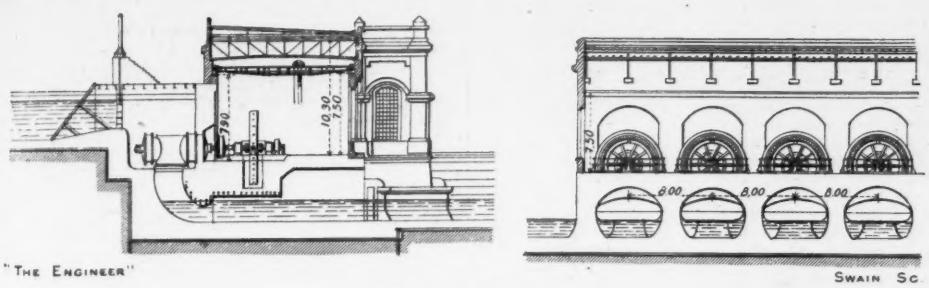


Fig. 7—THE POWER HOUSE



Figs. 8 and 9—THE POWER-HOUSE

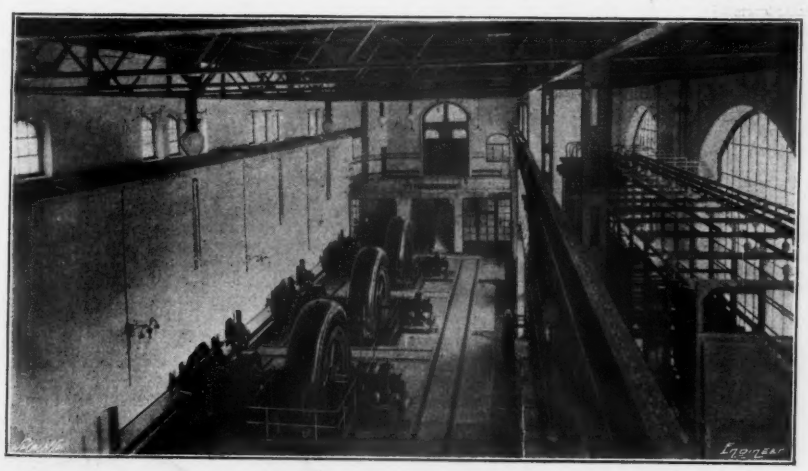


Fig. 10—INTERIOR OF POWER-HOUSE

Fig. 11—ZODEL FLEXIBLE COUPLING

south-west. There is also a transformer station for a 25,000-volt circuit 50 kiloms. in length, which passes to the north.

In the districts already at work the current is used mostly for lighting plants. In a few years' time current will also be required for the railway, which is now planned, running from Basel to Burgdorf; a further market for the current will be found upon the left bank of the Rhine, where it will be needed for driving the machinery in several German textile factories. The

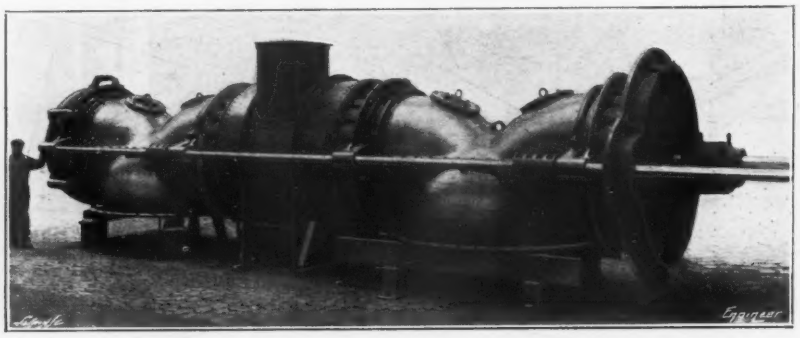


Fig. 12—DOUBLE FRANCIS TURBINE

accompanying illustrations and those on page 552 show various views of the hydraulic and electrical works of this interesting power station.

PRODUCTION OF CONTINUOUS ELECTRICAL OSCILLATIONS.

On Tuesday evening a lecture was given at the Queen's Hall by Mr. Valdemar Poulsen on the production of continuous electrical oscillations and their employment in wireless telegraphy. The chair was taken by Sir William Preece, K.C.B., F.R.S. Among those present were Princess Louise, the Duke of Argyll, Lord Armstrong, Sir Oliver Lodge, Dr. Nansen, and representatives of several of the Government departments. After a few brief remarks by Sir William Preece, Mr. Maskelyne read the paper for Mr. Poulsen. The paper described a system for producing undamped waves, and also gave facts concerning the utilisation of these waves in wireless telegraphy. It was stated that undamped electric waves have proved themselves suitable for a system of wireless telegraphy; that, as compared with the limited possibilities offered by the spark telegraph, many stations may simultaneously telegraph across the same territory without interfering with each other, and to this was added an enormously increased radius of signalling for a given power. The author stated that his success was due to ascertaining the peculiar properties manifested by an electric arc when immersed in an atmosphere composed of or containing hydrogen. By surrounding an arc with hydrogen a frequency of a million or more vibrations per second had been obtained. With coal gas or hydrogen it was possible to obtain frequencies higher than with the vapour of alcohol. Ammonia also gave good results. It was thought at first that the particularly advantageous influence of the hydrogen on the arc was due to the great cooling power of that gas. However, the high atomic velocity of hydrogen results in a great thermal and electrical conductivity, which, it was said, was probably the chief factor involved in the specific influence exerted by the gas. When the arc in hydrogen was placed in a magnetic field, the potential difference of the electrodes became very great in proportion to the length of the arc. For instance, 440 volts may correspond to a length of arc of 3 mm. Under those conditions the self-induction in the oscillation circuit could be increased considerably in relation to the capacity. This brought about a very considerable rise of potential between the plates and the condenser. It was stated that carburetted hydrogen gave a better effect than pure hydrogen. Coal gas or hydrogen which had been carburetted by passing through a reservoir containing naphtha was generally used.

A number of interesting experiments were then performed. Mr. Poulsen had several generators for producing continuous electric oscillations. First, some experiments of resonance with such oscillations were demonstrated. The author took a small oscillation circuit from which continuous electric waves were radiating. At a distanse of about 1 m. there was a small receiving circuit having a natural periodicity of about 700,000 oscillations per second. When the generating circuit was tuned to that frequency the receiving circuit responded, and a vacuum tube inserted in it became strongly luminous. The slightest variation of the frequency at once caused the activity of the receiving circuit to cease. The next experiment showed the great tension obtained in an oscillation circuit which had a great self-induction in comparison with ts capacity. The feed current had a potential of about 450 volts. By using two oscillation circuits with the same rate of oscillation, connected in parallel with the arc, but arranged in reversed symmetrical order, double the tension was obtained. With another generator, the oscillation circuit of which was connected directly to a resonance coil whose frequency was in agreement with that of the generator circuit—about 170,000 oscillations per second—stationary oscillatlons were produced with maximum tension at the top of the coil. A long, peculiar, soundless flame was obtained.

The author has utilised this new kind of electric waves for the purposes of wireless telegraphy. In the paper he described the devices employed, and their manner of operation, as follows:—"First there is the transmitter. In this there are two things of special interest, the coupling and the signalling. As regards methods of coupling, it may be said that the same may be used here as in the case of spark telegraphy. The antenna and its counter capacity may be made to act as the oscillation circuit in which the arc is inserted, so that the oscillations are created in the antenna, through a close or a loose coupling from a primary generating circuit. If the coupling be neither absolutely close or loose, the frequency of the system will not be sufficiently defined, since the arc may develop one or two periodicities not very dissimilar. We therefore generally use a very close or very loose coupling. In this connection the difference between the old and the new system manifests itself in a marked degree. If in the spark system it is attempted to attain any result in the way of selectivity, a loose coupling is essential, and thus a considerable waste of energy is involved. In the new system the tuning is equally sharp with either a close or a loose coupling."

Mr. Poulsen then went on to describe the methods of signalling that could be adopted. Referring to the receiver of the continuous waves, the author remarked that it was of prime importance to utilise the principle of resonance to the utmost. It was therefore necessary that the receiving system should include an oscillation circuit with the least possible damping, and, consequently, in loose connection with the antenna circuit. Owing to the continuity of the waves that were to excite the receiving system to osoillation, the detector was arranged in such a way that it only intermittently formed part of the circuit of oscillation. Thereby that damping is avoided which the permanent inclusion of the detector would introduce. The apparatus which causes the intermittent contact was called a "ticker." The most sensitive that has hitherto been dealt with consisted of an oscillation circuit, the condenser of which was intermittingly shunted by a condenser of comparatively large capacity placed in parallel circuit with a telephone. The receiving system may be said to be characterised by the small damping in the secondary circuit, the loose coupling to the antenna, and also somewhere in the receiving system a periodical variation which is preferably produced by an intermittent contact.

Numerous experiments have been carried out for the sending and receiving of messages. With an improvised installation of three receivers in connection with the same antenna, three different telegrams were received simultaneously without any mutual interference; the difference in the wave length in that instance amounted to between 3 and 4 per cent. Seeing that the generator gives a spectrum of electric waves extending from, for instance, 300 m. to 3000 m. in wave length, the number of stations which may now be worked over the same territory amounted to several hundred. In June, 1905, the first sending station at Lyngby, near Copenhagen, was ready for use, and, in order to experiment across the whole width of Denmark, another station was erected at Esbjerg. Communication was established the first day that the installation was complete. The distance was 180 miles, and the waves chiefly travelled across dry land. The signals were plainly intelligible in the telephone, even when the consumption of energy was only about 800 watts, and the energy radiated about 100 watts; the difference of potential between the antenna and earth is then only a few thousand volts. The wave lengths for these experiments lay between 700 m. and 1000 m. Later on by strengthening the magnetic field of the arc, with a wave length of 882 m., Mr. Poulsen obtained a radiating power of about 400 watts, which produced a powerful effect at Esbjerg.

On once occasion the Esbjerg station was fitted up to receive signals transmitted by spark telegraphy. Instead of the uninterrupted communication formerly obtained, the receiver gave out an inextricable jumble of English and German signals from land and ship stations; and in addition to that hopeless entanglement, the situation was complicated by the constant interposition of atmospheric discharges. In reverting to the new method, the communications with Lyngby were instantly restored without any disturbance from extraneous sources. Recently, with a power of about 1 kilowatt, perfect communications, it was said, had been established, both during day and night, between Copenhagen and North Shields, a distance of 530 miles—150 of which are overland—with a height of mast of only 100ft. The author is of opinion that transatlantic communication should be readily obtained with a power of some 10 kilowatts. The author, in conclusion, remarked that undamped and continuous wave-trains presented very great possibilities in relation to wireless telephony. There were so many ways of varying the length and amplitude of the waves, that some day it would be possible to produce a wireless telephone. The proceedings concluded with a vote of thanks to the author of the paper, and to Lord Armstrong, who had organised the lecture.

INSTITUTION OF ELECTRICAL ENGINEERS, GLASGOW LOCAL SECTION.

The fifth annual dinner of this local section of the Institution was held in the Grosvenor Restaurant, Glasgow, on the evening of the 27th inst., Lord Kelvin, the chairman of the section, presiding.

After dinner and the usual loyal toasts, Professor Archibald Barr, of Glasgow University, submitted "The Imperial Forces," which was responded to by Engineer-Commander Jenkin. "The Institution of Electrical Engineers" was proposed by the Bishop of Glasgow and Galloway, and replied to by Dr. Glazebrook, who said that much of the success of electrical science was due to the gentlemen whose portraits were printed on the cards in the hands of the company, Kelvin and Faraday. He questioned, however, whether they were all co-operating as fully as they might to advance the real interests of the Institution. Mr. W. M. Mordey, in also responding, described the West of Scotland as the home of electric traction, recalling that, in 1837, the first practical demonstration of it was made by Robert Davidson on the Glasgow and Edinburgh Railway.

In proposing "The Glasgow Local Section," Professor Jack made a number of complimentary references to Lord Kelvin. From the time when he entered the University to the present seventy years had elapsed, and during that period he had fulfilled all the great offices that could be filled by a great scientific man in this country. Lord Kelvin, he said, was the head and front of the great enterprise which made it a possible and practical thing to transmit, as an intelligent and intelligible message, the slightest tremor on this side of the Atlantic to the other side. His work for navigation had been spoken of all over the world. He imagined that the verdict of the world upon Lord Kelvin was reasonably and impartially expressed by the deputation of foreign engineers which came to Glasgow last July, when the Italian delegates brought Lord Kelvin two magnificent volumes containing records of the work which had been recently discovered in Milan of Leonardo da Vinci.

Lord Kelvin, who was loudly cheered on rising to respond to the toast, after expressing his intense interest in, and thanks for, the kind references which had fallen from Professor Jack to himself, said these references covered his connection with Glasgow University from his first entry into it in 1832, when, as a child, he was an inhabitant of the old college in High-street—living in his father's house; his father being then professor of mathematics—proceeded to remark that electrical engineers knew what their every-day business was, its practical application of science; but they were all scientific men and would sympathise with every application of their science to extend human thought through the remotest parts of the universe, and take an interest in abstract speculations, such as the formation of concrete matter from atomic origin. That did not sound very practical; it was not very like the daily business of an electrical engineer, but electrical engineers were scientific men, and could not help going beyond their daily range. One of our greatest electrical engineers, Sir William Siemens, showed that—he did not say he could lift his mind—he was elevated by his mind from his daily practical work into grand speculations far beyond anything that this earth could show of the properties of matter. Dr. Glazebrook had spoken that night of the time when there was no Institution of Electrical Engineers, but when there was a Society of Telegraph Engineers. It was considered at that time that the word "engineer" was scarcely touched by the delicate apparatus of the electric telegraph. They had not heard watchmakers called engineers, but they had had watchmakers and workers in that domain, such as Wheatstone, whose prodigious practical knowledge of dynamics led him to see in the small mechanism of a watch the means of bringing out electrical results, such as 250 words per minute of telegraphy. That and submarine telegraphy constituted the subject matter and engaged the ideas of persons connected with electric telegraphy. He thought Sir William Siemens was the first to give them the name of engineers. Sir William was certainly the founder—he believed he was right in that—of the Society of Telegraph Engineers, which soon after became the Institution of Electrical Engineers. He remembered particularly how they first heard from Siemens of very large things proceeding from telegraphic work. But they heard from others as well. There was Jacobi, of St. Petersburg, who had an electric boat driven by an electro-magnetic engine before the time of Sir William Siemens. That, perhaps, was the first piece of real electric engineering in the ordinary understanding of the word "engineer"—the applying of electricity to large forces for the benefit of mankind. He still remembered Sir William bringing before the Institution—he thought it then was of Telegraphic Engineers—the means of developing forces at a distance of ten, twenty, and thirty miles. The transmission of forces was, he believed, due—he meant practically the first inception of the idea, and the first bringing of it to a practical conclusion or advancing towards it—to Sir William. He remembered him telling of work done in the factory at Greenwich in which they had had extraordinary tantrums—if he might use the expression—performed by the series dynamos that they then had. Those present knew what sort of thing that was if used as a generator to charge a battery, or even to drive a motor at a distance. Sir William, and those who worked with him, devised the shunt dynamo, and had made one which had got over all their troubles; but his workpeople were so averse to it as such a new thing that he had difficulty in getting them to make another. He (Lord Kelvin) begged Sir William to make one for him. He did so, and during six or eight years, at least, it was working in a little room adjoining the physical laboratory of the University of Glasgow. It was driven by a Clerk's gas engine, which did its work well. He believed that really the first thoroughly practical electric lighting that was done anywhere was done by this Clerk's gas engine and Siemens' shunt-wound dynamo. He believed that the first house on this planet in which the whole lighting was done by electricity was a house in the University of Glasgow, getting the current from the Siemens dynamo and Clerk gas engine. In that house the rule given to the workers for making what began to be called "installations" soon after, was "Go through the whole house. Wherever there is a gas burner put in an electric light." There were 106 gas burners, and there were 106 electric lights in that house about the end of the year 1881. There had been houses partially lighted in London. In Mr. Spottiswoode's (then the President of the Royal Society) there were six electric lights shown and used in one room in the house. Edison had lighted rooms in houses in America. He had never heard, however, that any house was wholly lighted by electric light at that time. From this beginning a very large spreading out of the electric light quickly followed. The University of Glasgow might look upon the fact with some interest that a house in the University had its whole electric lighting done in the way and at the date explained. It was not lighted the whole twenty-four hours. A little before midnight every night he used himself to go across to his laboratory and stop the gas engine, and anyone that wanted a light in the house must have a candle, because the gas had been cut off and soldered up. In closing, his lordship briefly referred to the progress of electrical engineering. From 1875 to 1905 there had been prodigious development of activity in the applications of science for the good of mankind.

MOTOR CAR EXHIBITION AT OLYMPIA

No. II.*

The six-cylinder engine built by Rolls-Royce, Limited, Manchester, has cylinders cast in groups of three. It is calculated to give between 40 and 50 horse-power on the brake, and has cylinder dimensions 114 mm. by 114 mm. The crank shaft is large and hollow, and is supported between each pair of cranks. Forced lubrication is provided through the shaft. The valves are all on one side and operated from one cam shaft. The inlet and exhaust valves are interchangeable. The clutch is of the internal cone type, of large diameter and wide face. To ensure concentricity it is self-contained. The change speed gears are of the sliding pattern, giving four speeds forward and one reverse, but the direct drive is on the third speed—the one that is chiefly used. From the gear-box the motion is transmitted to the live axle by means of bevel and differential gears. The axle consists of a central substantial aluminium case containing the bevel gears and the differential, and attached are two solid drawn steel tubes, flanged and bolted to the aluminium case. Upon each of these tubes is mounted a road wheel which revolves on ball bearings. Inside the tube is the revolving shaft driving the road wheel from the differential situated in the bevel gear case. On the ends of the driving shafts are solid keys, and on the keyed portion is fitted a jaw clutch which engages with suitable teeth cut in the outer end of the road wheel hub. This construction utilises the strength afforded by the large diameter of tube and avoids the bending stress set up by repeated reversals.

The Wolseley Tool and Motor Car Company, which has now entirely abandoned the use of the horizontal petrol motor, shows a variety of new patterns of cars with vertical engines. The range includes a 10 horse-power live axle car with two cylinders, 4in. by 4½in.; a 15 horse-power live axle car with four cylinders, 4in. by 4in.; an 18 horse-power chain-driven car with four cylinders, 4¼in. by 4in.; an 18 horse-power live axle car with four cylinders, 4in. by 4½in.; a 30 horse-power car with live axle and four cylinders, 4⅜in. by 5in.; a 40 horse-power chain-driven car with cylinders 5¼in. by 5in.; and a 45 horse-power six-cylinder car with cylinders 4⅜in. by 5in. and chain driven. The chief feature of the 10 horse-power car is the thermo-syphon system of water cooling, no pump being used. The six-cylinder engine has the cylinders in pairs, and the crank shaft has four bearings. The clutch is of the cone type, metal to metal, and there are four forward speeds—the direct drive, as in the Rolls-Royce, being on the third speed. The induction and exhaust valves are mounted underneath on the same side of the motor, and are interchangeable. The valve operating plungers are fitted with rollers. A centrifugal governor operates a balanced throttle in the mixture pipe. An automatic equalising carburetter is supplied with petrol under pressure from the tank, this pressure being maintained through an automatic valve in connection with the engine exhaust. A hand pump is fitted for obtaining initial pressure before starting.

The firm of E. H. Bentall and Co., Maldon, Essex, is a newcomer in the motor industry, and is introducing three inexpensive types of car, in which the vertical petrol engine is used in each case. The 9 horse-power and 11 horse-power cars have two cylinders, and the 16 horse-power cars four cylinders. The four-cylinder engine has cylinders 90 mm. by 95 mm., with valves on opposite sides, and gives 16 horse-power at 1200 revolutions per minute. It is fitted with low-tension magneto ignition. The cylinders are cast singly. For lubricating the big-end bearings and pistons pressure feed by means of the exhaust gases is provided. The clutch is of the internal metal cone type running in oil. It is dust-proof, and runs on ball bearings. Perhaps the two most noteworthy features of the Bentall cars are the method of rigidly connecting the change-speed gear-box and the rear axle, and the means adopted whereby, with the use of an ingenious form of quadrant, the change-speed lever is prevented from being "run through" the different notches—a cause of trouble with the usual quadrant, and one which the newer form of gate movement was intended to replace. In the Bentall car the push-through is prevented by the side movement of the lever and a clamping action of the members of the sector. The rigid connection of the gear-box with the back axle is effected by means of tie rods—Figs. 17 and 18—and there are no universal joints which are liable to wear and become noisy. It is also claimed that friction is reduced, that there is no necessity for torque or radius rods, and that no distortion of the cardan shaft is possible. With regard to the ignition system, an arrangement is provided whereby the spark can be retarded when starting the engine. Means are also given for regulating the sparks in each cylinder, and also for taking up wear, while the whole system being on top of the cylinder can be easily removed. A special trip gear enables the break of the contact of the hammer with the plug to be rapid when the engine is turned by hand, so ensuring ease of starting. The gear-box—Fig. 19—provides three speeds of progression, the changes being made by a single sliding member shown, and there is a direct drive on the top speed. Ball bearings are fitted throughout. The box is designed to prevent loss of lubricant, and the operating rod is placed on top. There is a large inspection door, and the gear wheels are cut out of solid steel of special quality. The back axle is fitted with ball bearings throughout, and the differential gear is of the spur type, extra large and strong. The road wheel brakes are of the expanding type, capable of exerting equal force in either way and they are compensated and dust-proof.

Several improvements are embodied in the 30-40 horse-power Crossley car shown by Charles Jarrott and Letts, Limited, Great Marlborough-street, London, W. From a view of the chassis given in Fig. 20, it will be observed that a live axle is provided. The engine has four cylinders, 4¾in. by 6in., cast in pairs. The valves are on opposite sides and interchangeable, and a simple half-compression gear is fitted to make starting more

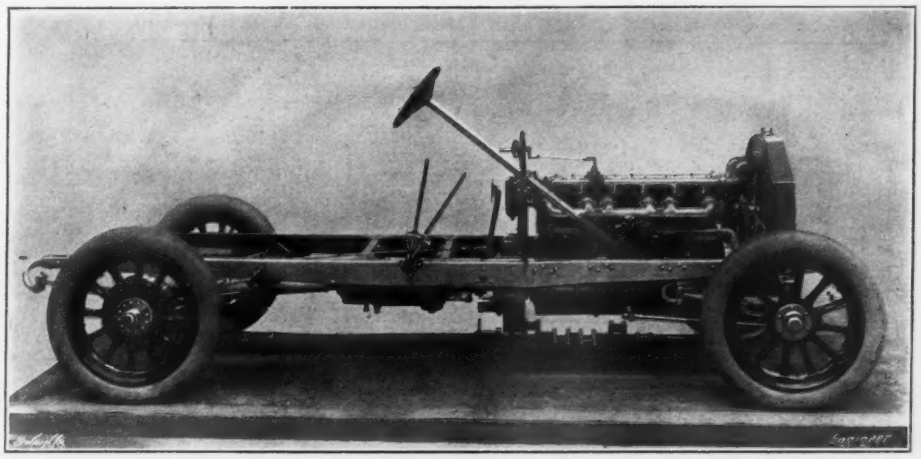


Fig. 16—60 H.P. SIX-CYLINDER BELSIZE CHASSIS

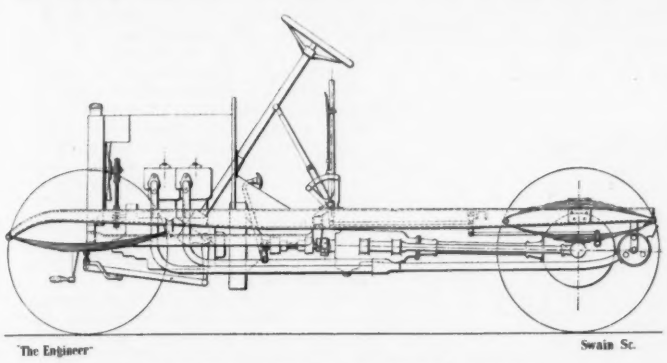


Fig. 17—SIDE ELEVATION OF BENTALL CHASSIS

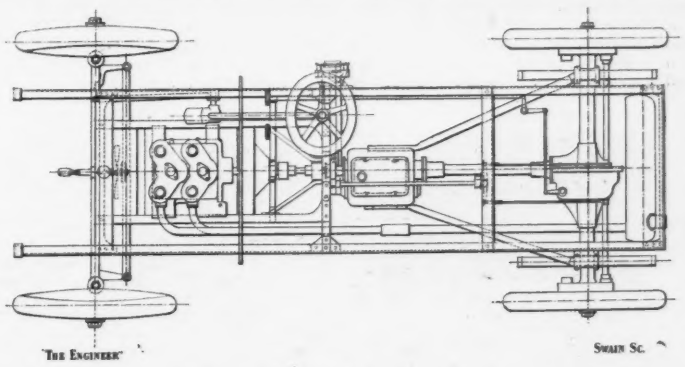


Fig. 18—PLAN OF BENTALL CHASSIS

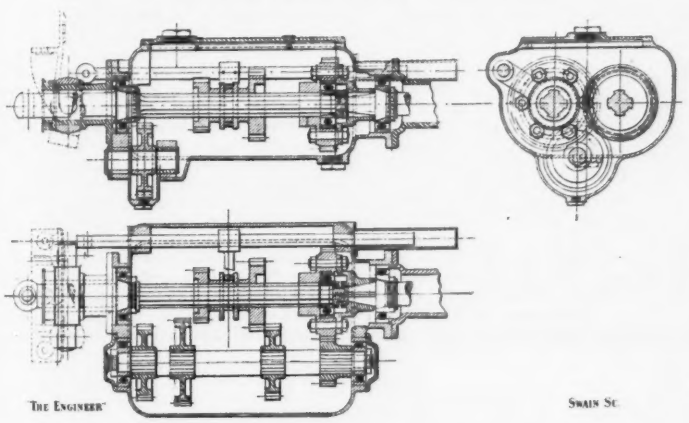


Fig. 19—BENTALL GEAR BOX

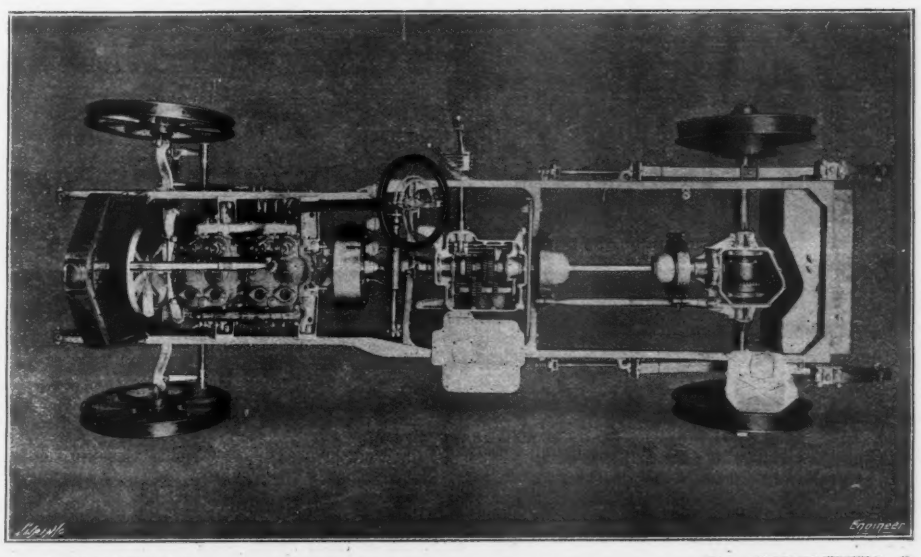


Fig. 20—CROSSLEY FOUR-CYLINDER CHASSIS

* No. I. appeared November 23rd.

easy. The clutch is of the expanding metal-to-metal type, which has proved so successful. The gear-box is of a new type, the gear wheels being contained in a box with only one horizontal joint, that for the top cover. The gear shafts are entered into and withdrawn from the box by removing a circular flange. This flange contains a

The Britannia Engineering Company, of Colchester, has entered the ranks of the motor car builders and exhibited at Olympia a four-cylinder car with several commendable features. Views of the chassis are given in Figs. 21, 22, and 23. The object of the builders is to provide a fairly high-powered vehicle embracing the best modern practice at a moderate

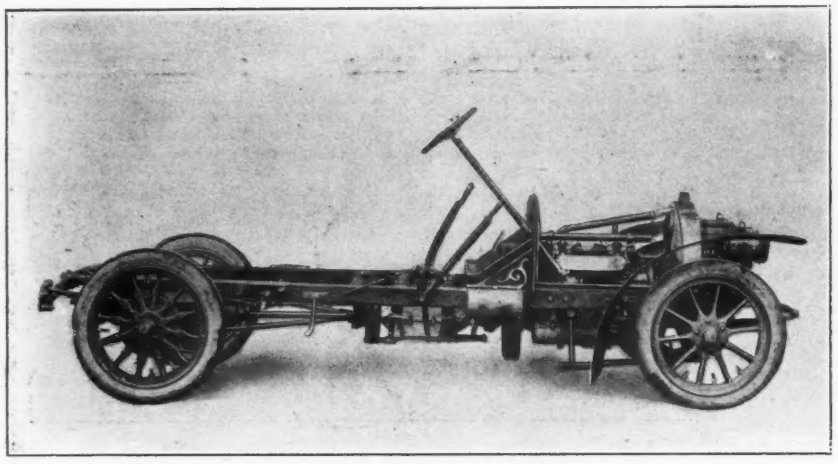


Fig. 21—SIDE VIEW OF BRITANNIA CHASSIS

stuffing-box and gland, which can be tightened up on felt packing as required. The selector or operating gear all lies in the bottom of the box, and the gears can be removed without disturbing any part of this. The transmission to the rear axle is by a propeller shaft universally jointed at both ends. The rear axle is of exceptional

price, and judging from a short trial run we have had on a Britannia car, together with a close inspection of the mechanical features, the makers may be said to have succeeded in no small measure. The engine of the 18-24 horse-power car has four vertical cylinders cast in pairs, 104 mm. by 130 mm., giving a maximum of 30

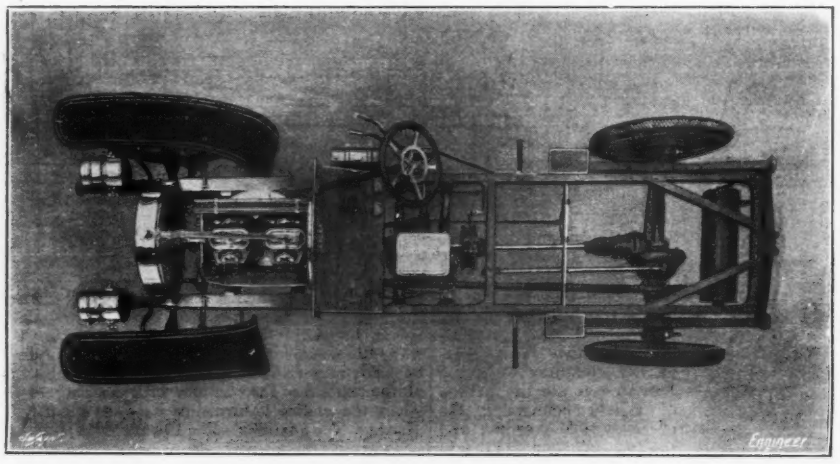


Fig. 22—PLAN OF BRITANNIA CHASSIS

strength, and the road wheels are carried on the tubes or outer casing, through which revolve the driving shafts. These shafts do not carry any weight, but only communicate the drive to the road wheels through star clutches in the hubs. These shafts can be withdrawn by removing the hub caps and a small clip. The whole of the differential gear can thus be taken out by removing the cover of the outer casing and two clips inside. This can be done without disturbing either road wheel, springs, or any connections.

brake horse-power. The valves are on opposite sides, and are operated by cam shafts in the crank chamber. The engine is bolted directly to the main frame of the chassis, and not to a separate frame, as is customary. The motion is transmitted through a leather-faced cone clutch with flat expanding springs between the leather and the metal to the gear-box. A simple method of adjusting the tension of the clutch spring is provided. This is effected by turning a split brass nut. The gear-box includes three speed gears and a reverse, and the shaft bearings are plain but long. From the gear-box the motion is transmitted by bevel gearing and differential to the live axle. The propeller shaft is carried in floating bearings, and the axle is carried on Hoffmann ball bearings. Special attention has been paid to facilitating the lubrication of the back axle, and accessibility to the vital parts of the engine has been well considered. Low tension magneto ignition is fitted over the inlet valves, and the spark can be inspected or adjusted by the removal of a simple cap. The lubrication to the crank chamber, cylinders, and to the main bearings of the gear-box is fed by pressure. The engine has no automatic governor, but a butterfly valve is provided in the mixture pipe, which is partially closed when the clutch is thrown out, to prevent the engine racing. The brakes are well designed. The foot brake is of a powerful internal expanding pattern acting on the propeller shaft, and is applied without withdrawing the clutch. This is an important feature, as it allows the engine to be used as a brake with advantage. The hand brake acts on the wheel hubs through equalising levers, and the operation of this brake withdraws the clutch. The crank chamber of the engine is easily inspected by means of doors, and the half-time gear wheels and the wheels for working the pump and magneto are all enclosed. The springs carrying the frame are long, the long plate springs over the back axle being connected at the rear of the car by a transverse spring. The complete control of the car is afforded by two levers and sectors on top of the steering wheel. The petrol is supplied to the carburetter by gravity, and the fan behind the circular radiator is mounted on an excentric bearing to provide an easy method of tightening the belt.

Considerable interest was taken in the self-starting appliance fitted on a 60 h.p. six-cylinder chassis shown by F.I.A.T. Motors, Limited, Long-acre, London. The force necessary for starting the engine is supplied by compressed air obtained from a tank. The pressure in this is maintained by a vertical pump placed in front of the first engine cylinder and operated by a connecting-rod from the crank shaft of the engine. The pump cylinder is water-cooled. The air, under a pressure of about 12 atmospheres, is introduced into the engine cylinders at starting through valves actuated by means of rods from the exhaust valve cam shaft. These air valves are opened in their correct rotation until each of the cylinders has received its share and the crank shaft has been turned by the pressure on top of the pistons. The mixture of gas is then introduced and ignited in the usual way and the air supply shut off. Further use can be made of the air compressor for inflating tires by connecting the reservoir to the tire valves by means of rubber tubing.

Fig. 16, on page 547, represents a view of the 60 horse-power six-cylinder chassis shown by Belsize Motors, Limited, Clayton, near Manchester. The design and workmanship are alike highly creditable. The engine cylinders are 5in. diameter by 5in. stroke, and are cast in pairs. The cooling system is thermo-syphonic, no pump being used. This system has been adopted after the makers have thoroughly satisfied themselves as to its efficiency. The valve-operating mechanism is placed on top of the cylinders. The control levers are carried on the steering wheel, but by means of an independent lever fitted on dashboard a sliding motion is given to the cam shaft, bringing into play two separate series of cams by which the lift of the inlet valves can be varied. By means of the above-mentioned lever the cam shaft can also be moved into position for lowering the compression to secure ease in starting. Two ignition systems are provided, by magneto and by accumulators. When using the accumulators a special trembler coil is provided, and by a special arrangement of commutator fixed on the dashboard the times of firing in the cylinders are absolutely synchronised. A double switch is supplied so that either set can be used at will. This car is fitted with a metal-to-metal clutch, which runs in oil. The lubrication is on the dredger system, by which the feed of oil to the engine is in proportion to the speed, and a positive delivery is ensured to every part of the motor. Lubrication by this system is stopped whilst the motor is at rest. Three forward and one reverse gear are provided, all changed

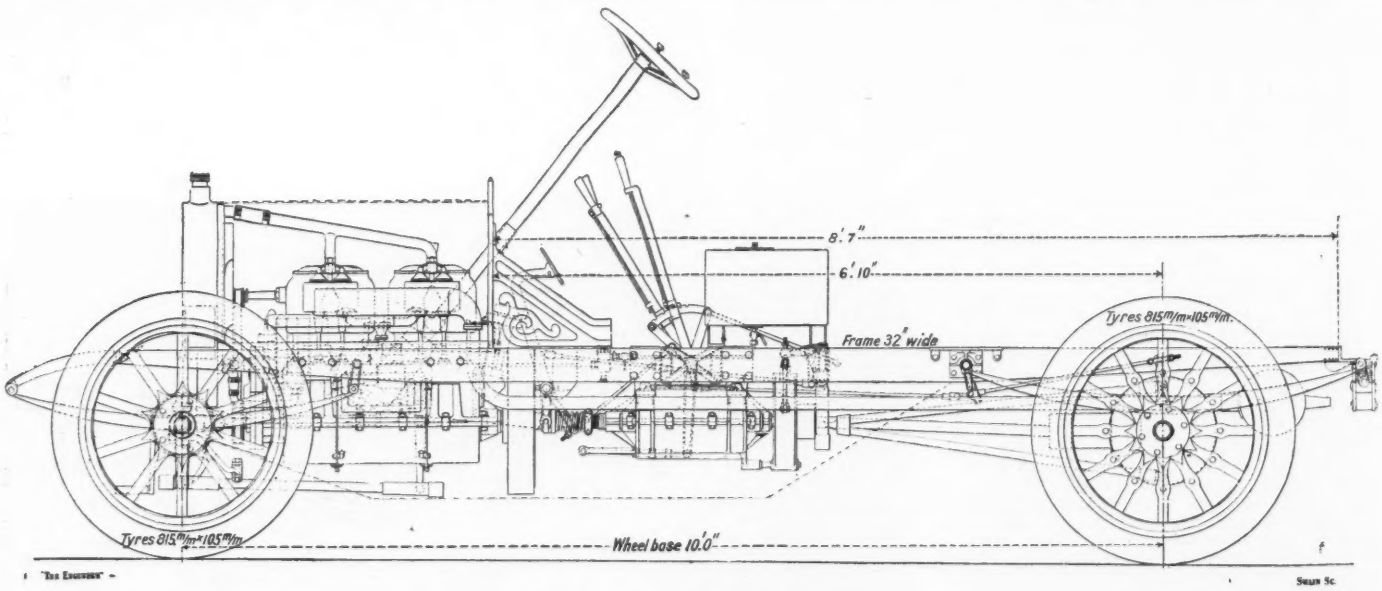


Fig. 23—ELEVATION OF BRITANNIA CHASSIS

by means of one lever. On the top speed the engine drives direct through the gear-box without the intervention of any gearing, thus saving both friction and wear and tear, and securing smoothness of running. The transmission from the gear-box to the back axle is effected through a universal joint and a pinion shaft carried through a long sleeve direct to the bevel in the centre of the back axle. The latter is of exceedingly strong type, and wherever possible keys have been dispensed with.

bearing between each cylinder, and the main clutch is of the multiple disc type in an oil-tight casing. New features have been introduced into the change-speed gears, and those that are always in mesh are of the helical pattern, while the sliding gears have ordinary spur teeth. Three speeds are provided, including a direct drive on the top speed, and the changes are effected by a single lever designed so that it is impossible to miss engaging under any conditions. The back axle is built

being placed under the bonnet on each cylinder, an arrangement is provided for switching off each cylinder independently from the dashboard when running.

Amongst the latest converts to the six-cylinder petrol engine—Figs. 24, 25, and 26—is the Thames Ironworks, Shipbuilding, and Engineering Company, Limited. A car so fitted has an engine with cylinders 4½in. by 5in., developing 45 horse-power at 1050 revolutions. The cylinders are cast in pairs, and the pistons have each four

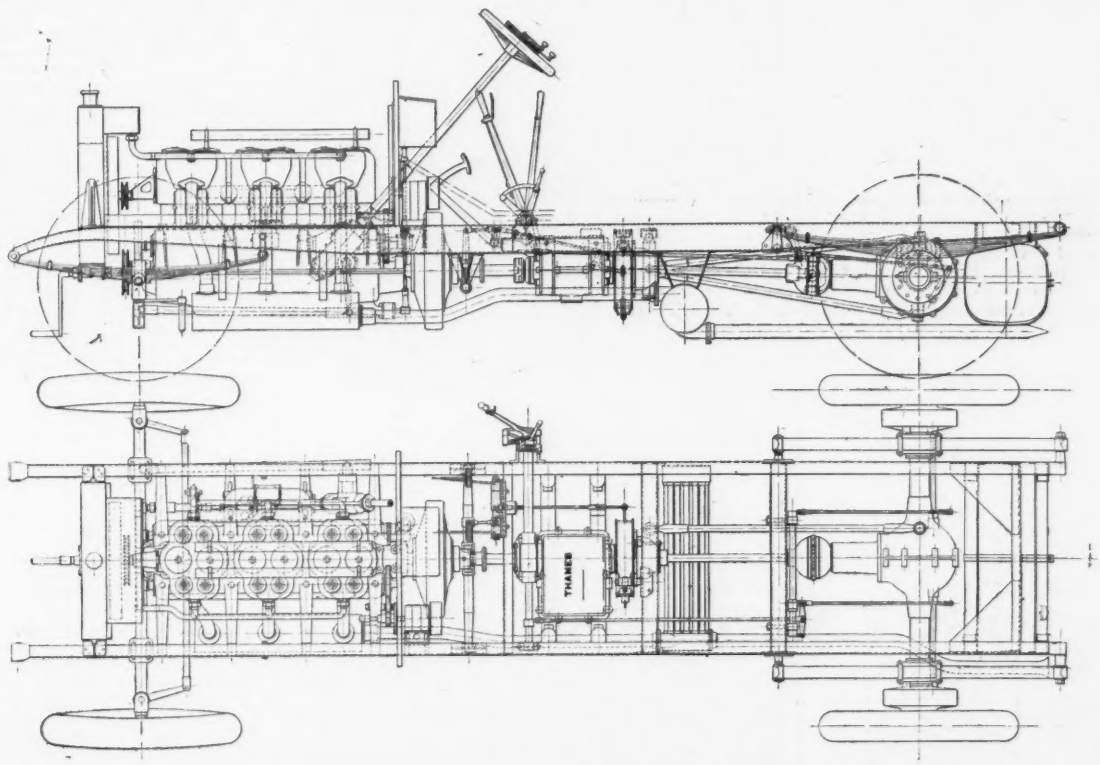


Fig. 24—ELEVATION AND PLAN OF THAMES IRONWORKS 6-CYLINDER CHASSIS

The firm of Sir W. G. Armstrong, Whitworth and Co., Limited, introduced a new type of petrol car which has numerous noteworthy features. Unlike their earlier vehicles, the present one has a vertical engine, with four separate cylinders 5in. bore by 4in. stroke. The induction and exhaust valves are placed on opposite sides, are interchangeable, and of large dimensions. The crank chamber and gear case are one casting, surrounding

up with an aluminium casting in the centre, and two steel tubes. These tubes carry the brake brackets, and on the extension of these tubes rest the ball bearings, on which the road wheels run. The construction of the aluminium casting is such that the top can be removed while the axle still carries the weight of the car. The drive is transmitted from the differential gear to the road wheels by hollow nickel steel shafts which pass through

rings—three at the top and one at the lower end. The gudgeon pin is secured by a steel bush let into the piston similarly to the rings, thus obviating the use of bolts and nuts. The connecting-rods are of forged steel of circular section, the large end having a white metal bearing and the small end a hardened steel bush. The crank shaft is of nickel steel, 60 tons tensile strength. Lubricating holes are drilled between the crank shaft bearing and the

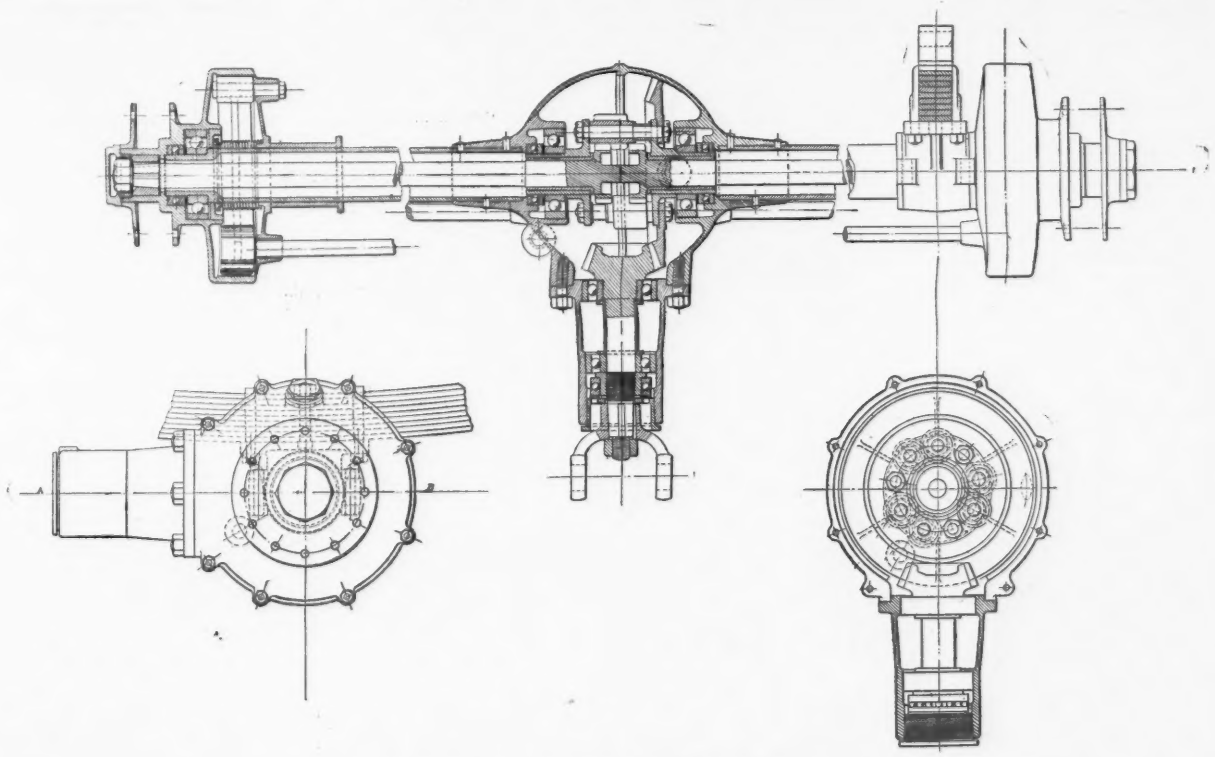


Fig. 25—DETAILS OF LIVE AXLE, THAMES IRONWORKS CAR

the fly-wheel and clutch. A centrifugal governor on the inlet valve cam shaft advances or retards the ignition to synchronise with the speed of the engine. Another peculiar feature of the Armstrong-Whitworth engine is the regulation of the gas mixture by the water pressure produced by the circulating pump. Every part of the engine is easy of access, and the carburetter can be opened without the use of tools. The crank shaft has a

the centre of the steel tubes, forming the axle proper. The drive from the propeller shaft is transmitted to the differential gear by a helical cut pinion and bevel wheel. The differential gear is of the parallel type, and the wheels are also helical. Two systems of ignition are fitted—low-tension magneto with automatic advance, and a stand-by high-tension with single trembler multiple coil. Instead of the usual low-tension cylinder cut-outs

connecting-rod bearing, for the forced lubrication. The crank shaft is carried in four bearings, with a large wearing surface. The inlet and exhaust valves are mechanically operated by separate cam shafts, placed on opposite sides of the cylinders, and driven by wheels made of special fibre. The crank chamber is cast in aluminium with large inspection doors. The aluminium oil chamber bolted to the crank chamber is constructed with

two compartments, one containing oil for splash lubrication, so arranged that when the car is either on the flat ascending or descending a hill, the level of oil is practically constant, thereby eliminating insufficient or excess of lubrication. The other compartment contains oil for providing a positive system of lubrication to all bearings by means of an oil pump driven by skew gear from the cam shaft. The carburetter is of the multiple jet type fitted with a sliding throttle valve, which governs the number of jets to suit requirements, the sliding throttle being regulated by lever and ratchet on the steering wheel. The body of the carburetter is water-jacketed, and the temperature can be varied. A metal-to-metal cone clutch is used, grooves being cut in the face of the cone into which the oil is forced as the clutch is engaged. The change-speed mechanism provides the usual three forward speeds and reverse, the motion being transmitted directly to the live axle on the top speed. In addition, by means of a special striking device the countershaft is simultaneously thrown completely out of mesh when on the top speed. The various gears are engaged by one lever working in a gate quadrant. Universal couplings of special design are fitted at both ends of the propeller shaft. They have four driving pins, having one common centre with the star block, and kept in position by a special device. The propeller shaft is of nickel steel. The live axle is driven by bevel gearing, and the differential gear is of the spur wheel pattern. The sun spur wheels are cut solid with the driven shafts, which have a dog clutch fitted on the end of each for driving the road wheels.

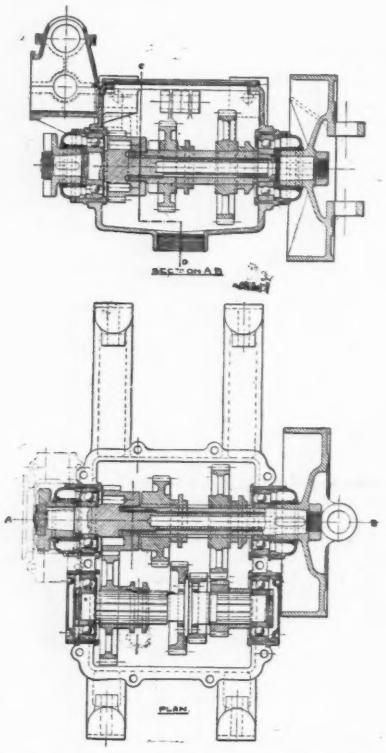


Fig. 26—THAMES IRONWORKS GEAR BOX

The design of the axle is such that the whole axle weight between the road wheels is carried by tubes fixed securely in the axle casing. Adjustable springs are fitted in the torque-boxes to absorb the torque of the live axle and the torsional stress caused by braking the road wheels.

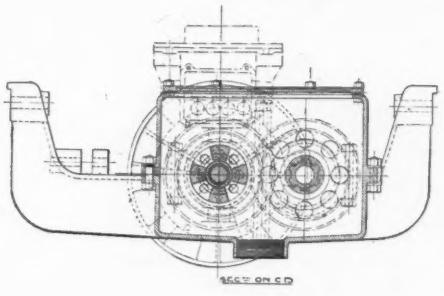
In the design of the silencer a departure from customary practice has been made. The result is said to be most effective. The exhaust pipes from the cylinders are fitted into an expansion chamber, from which a long pipe, with expansion joints, is carried to the silencer for further expansion. This is composed of two end drums. Connecting these drums are a large number of thin steel tubes, spanning the frame, and catching the cooling draught caused by the car. These are divided into several different units, the drums being constructed so as to make each individual set quite distinct. A final pipe, with a special shaped end, is carried to the rear of the chassis. An extremely large cooling area is thus obtained for the gases. It will be seen that the exhaust gases pass across the width of the car four times by the tubes, and meet with a large cooling surface before being discharged.

Two ignition systems are fitted, one being a synchronised high-tension, with accumulators, and the other a high-tension magneto, with independent sparking plugs. The synchronised distributor is placed on the dashboard, and is driven by spiral gear from the induction cam shaft. The contact breaker can be removed without disturbing the rest of the distributor, while a double jump spark on the high-tension circuit shows the working of the apparatus at all times. The magneto appliance is driven by fibre spur wheels from the exhaust cam shaft. The order of firing the charges in the cylinders is as follows:—1, 4, 2, 6, 3, 5.

Turner's Motor Manufacturing Company, Limited, Wolverhampton, exhibited the Turner-Miesse steam car, which has a three-cylinder single-acting engine and a flash boiler made in four sections, so that the bottom section, which suffers most in use, can be replaced at small cost. The burner is designed to burn ordinary paraffin as fuel, and a feed-water heater which utilises the exhaust steam to heat up the water on its way to the generator is now provided.

There were not many new features in tires and wheels, but the "Doolittle" detachable rim is worthy of notice. In place of the channelled rim surrounding the wooden felloe of the wheel, a steel rim, with shallow flanged sides, is shrunk on to the wood. The detachable rim is placed on the top of this. It is cut through at one point diagonally from base upwards, so that one end will slide over the other. This rim is furnished with two or three small projections on the under side, which bed against the channelled rim, and so enable it to be centred. The two ends of the rim are united by metal straps underneath, through slots in which a pin passes up through the centre of the wooden felloe of the wheel. This stud is furnished with two opposite excentrics, which engage with the two straps mentioned, and by turning this round in its socket with a spanner the split ends of the rim are drawn together. This is done until the excentrics have moved past their centre line of action, so that they are commencing to close down in the opposite direction, where, however, they come to a stop, and before they can loosen they must first increase—very slightly—the tension on the rim, which is impossible. There are no security bolts, but, in order to centre the two rims, and prevent any possibility of the one sliding off the other, at three or four points around the rim small key bolts are let into the wood felloe beneath the supporting rim, and excentrics upon these raise feather pieces through slots in both rims, thus preventing lateral movement.

Mention should be made of a new form of change speed gear, in which the motion is transmitted at right angles.



Lloyd's cross roller gear employs a large vertical disc, on which are secured four concentric lines of projecting rollers. The variations of speed are brought about by sliding a special form of pinion into mesh with one or other of the four sets of rollers.

OBITUARY.

HAZELTON ROBSON ROBSON.

We have to record with regret the death of Mr. Hazelton R. Robson, of Glasgow, who was well known in engineering and shipbuilding circles on the Clyde, and throughout the West of Scotland. Although in his eighty-fourth year, he was vigorous and active up till the time of his death, which occurred at 115, St. Vincent-street, Glasgow, on the 21st inst. An Englishman by birth, he received his early training and experience in engineering in the well-known works of Messrs. Hawthorne, Newcastle-on-Tyne, and on the Continent. At the early age of twenty-four he was offered a position of trust in the extension of Messrs. Hawthorne's works in Leith, and in this capacity he had to superintend some very extensive contracts. At the age of thirty-three he was appointed Engineering Surveyor to the Board of Trade for the Clyde ports, comprising the area from the Mull of Galloway to Oban. It was at his suggestion that the system of granting certificates to engineers after examination was instituted, and he was for a time the sole examiner for Scotland. On retiring from this appointment he became a member of the firm of David and William Henderson and Co., engineers and shipbuilders, and the rapid extension of that firm's business during the fifteen years that he was a partner was in great measure due to his energy and enterprise. He was one of the originators of the Institution of Engineers and Shipbuilders in Scotland—now in its jubilee year—and was president from 1874 to 1876. During his later years Mr. Robson was often appointed a commissioner to conduct the inquiries into causes of explosions, &c., and was a frequent arbitrator in disputes connected with shipbuilding and engineering. Up to the end he maintained an active interest in various business concerns. Even the day prior to his death he was engaged in the forenoon at a foundry in the west end of Glasgow, and was attending a meeting of directors later in the day when his life closed so suddenly. He is survived by his wife and three daughters.

PHILIP RUDOLF BJORLING.

We regret to have to announce the death of Philip Rudolf Bjorling, which took place after a brief illness at Littlehampton on November 27th. A native of Sweden, Mr. Bjorling came to England when a young man, and had been engaged as a pump specialist in this country for about forty-five years. He had been draughtsman with such firms as May and Mountain, John Fowler and Co., Leeds; Hayward, Tyler and Co., London; Joseph Evans, Wolverhampton; Fielding and Platt, Gloucester; and other of the leading establishments. The last three years, during which he was resident at Littlehampton, he was with Messrs. Duke and Ockenden, joining this firm primarily to develop a new type of pump of his own invention. He was the author of numerous books, treatises, and pamphlets upon his favourite subject of pumps, and had in his time contributed to many engineering and allied technical journals.

GEORGE LONGHURST.

Mr. George Longhurst, for nearly half a century at Messrs. Treggan and Co., Brewery-road, N., and for thirty-two years superintendent foreman, died, after a short illness, on the 16th inst., at the age of sixty seven. Mr. Longhurst was well known and highly esteemed throughout every branch of the trade, and his rather unexpected death is greatly regretted.

DEATH BY ELECTRICITY.

A curious case of death by electricity occurred on the 22nd inst. at the factory of Messrs. Turnbull and Stockdale at Ramsbottom. A fireman and engine-driver was engaged in his work, and was holding a hand electric lamp supplied with current by a twin flexible wire. He was suddenly heard to shout out, and before the current could be cut off he was killed. The factory is furnished with electricity by the Lancashire Electric Power Company. High-tension 10,000-volt three-phase mains are led into a transformer house, and the voltage reduced to 230 volts or thereabouts in transformers. Apparently, through various causes, the voltage is very rarely as low as 230, and is frequently as high as from 250 to 265 volts. The periodicity is 50 per second. From investigations carried out by an expert, employed at the instigation of the coroner, it seems certain that one of the leads inside the lamp came into metallic contact with the metal of the lamp holder. The transformers were Y-connected, and the centre point of the Y connected to earth. The lighting circuit was connected between one phase lead and the earthed return. The plates on which the unfortunate man was working were, of course, also connected to earth, and he was wearing clogs which were nearly certainly damp with a slightly acid solution, as he, in the course of his work, had to cross a floor wet with such a solution. In any case, between whichever parts of his body the current passed, it was clearly demonstrated at the inquest that a current with a pressure of some 250 volts had brought about his death. A post-mortem examination did not point to his being a man specially liable to electric accident or having an abnormally low resistance. We understand that it is the intention of Messrs. Turnbull and Stockdale to employ only from 50 to 100 volts for the future in the hand almps used in their factory.

NEXT YEAR'S RAILWAY COAL CONTRACTS.

Our Barnsley correspondent, writing on Wednesday, says:—Not since the year 1900, when at least two of the leading railway companies paid 16s. per ton for supplies for the second half of the term, has the interest attached to the contracts created such a flutter amongst coalowners and railway officials. Amongst the companies seeking supplies for next year are the North-Eastern, Great Northern, Great Central, and the Furness Railway Companies. The North-Eastern is seeking full supplies, amounting to something like 400,000 tons. The Great Central and Great Northern, it is understood, only want supplies to replenish part of their contracts falling out at the end of the year. The South Yorkshire Associated Coalowners have, by arrangement, tendered at 9s. 6d. per ton, being 1s. per ton on the tenders placed by several companies up to June next. The Furness Railway Company has closed with two South Yorkshire firms at something like quoted rates, but the North-Eastern and Great Central have offered 9s. per ton, which has been refused. Local coalowners contend they are entitled to the full advance demanded, as several steam coal contracts for supplies over next year have been placed at the advance asked. Attention is called to the fact that the North of England coalowners have tendered at an advance of 2s. per ton on current contract rates, and have had an offer of 1s. per ton advance, which they refused. The demand for South Yorkshire hards, such as is supplied to railway companies, is active, and despite the closing of some of the principal Baltic ports, a large consignment is sent to the seaboard. Most of the leading steam collieries are well contracted up to the close of the first half of next year, and, considering the outlook, they are inclined to be firm and await the ensuing shipping season, in connection with which few important contracts have yet been made.

A report has been received from Northern Mexico that a discovery of a new rubber-p oducing plant has been made in that vicinity. Guayale, by which name this plant is known, is low and bushy, and grows extensively at altitudes of 5000ft. in Northern Mexico and Arizona. It is gathered, roots included, dried, and baled in bundles of about 100 lb. each. Rubber is said to constitute about 15 per cent. of the dried plant. There are about six large factories for treating the plant in the vicinity of San Luis Potosi, Saltillo, &c.

Jubilee of the Siemens Open-hearth Furnace.—An invention which has done much for the advancement of the steel industry during the past fifty years is that of the Siemens open-hearth furnace. It is just fifty years on December 2nd since the late Mr. Frederick Siemens took out the original patent for an invention of an "improved arrangement of furnaces, which improvements are applicable in all cases where great heat is required." The invention consisted of arranging, smelting, and heating furnaces so that the products of combustion, on their passage from the place of combustion to the chimney, passed over an extended surface of brick, metal, or other suitable material, imparting heat thereto. This heat served to raise the temperature of the air in such a manner that the cold air or gases were first brought into contact with the less heated material, nearest the chimney, and were brought by degrees into contact with the more intensely heated portions until they finally passed over the surfaces nearest the place of combustion, which were, in consequence, heated to the highest degree. At the time the patent was applied for Mr. Frederick Siemens was assisting his brother, the late Sir William Siemens, who was then experimenting with his regenerative steam engine. Mr. Uchatius, who about this time was making trials with a new steel process, found difficulties in getting sufficient heat for his requirements, and Sir William Siemens introduced him to his brother Frederick, who designed him a furnace based on the above principles. The furnace gave excellent results; in fact, so great a heat was obtained that the crucible itself and the bricks of the furnace were melted together. This experiment early showed that a greater heat could be obtained on this new regenerative principle than had hitherto been possible. Mr. Frederick Siemens at once devoted his attention to perfecting his regenerative furnace, and subsequently several patents were taken out in the joint names of Charles William and Frederick Siemens. In three of the diagrams accompanying the original patent the flame is shown travelling continuously in one direction, there is a recuperator having three passages for heating the air and four passages for the waste gas or products of combustion. This kind of regenerative furnace has been applied on a large scale for heating gas retorts in gasworks, and more recently for heating steel ingots and billets. But for the higher temperatures Mr. Siemens always preferred his regenerative furnace with a reversible flame.

RAILWAY MATTERS.

THE Chicago North-Western Railway Company, Chicago, is stated to have decided to install on its locomotives mechanical stokers.

THE Cape Parliament have passed a vote for £50,000 to be expended in electric lighting on the Eastern and Midland Railway systems. The money will be principally expended on the Stone system of railway carriage lighting.

A *Times* telegram from Shanghai states that surveys have been begun by the Chinese for the new Che-kiang railway, which will run from Shanghai to Kia-hsing, where it will connect with the proposed line from Su-chau to Hang-chau.

THE returns of railway accidents and casualties, as reported to the Board of Trade by the various companies during the three months ended June 30th last, show that 265 persons were killed and 1549 injured, compared with 241 and 1323 in the corresponding period last year.

THE American Law Courts are steadily bringing to light grave mismanagement on the railway systems. Recently, for instance, the New York Central Railroad was convicted of granting rebates to the American Sugar Refining Company. The latter has been called up for trial on the charge of accepting rebates.

A TELEGRAM from Tokio to the *Times* states that the Japanese have decided to bridge the Ya-lu River at Yongampo. The bridge will have a span of 3239ft., and will cost £200,000. It will be completed at the same time as the Wi-ju-Mukden Railway, thus establishing direct communication between Mukden and Fu-san.

THE *Gazzetta Ufficiale* of November 16th contains a copy of a law authori-ing the Cremona and Borgo San Donnino Railway Company to construct a railway—steam traction—between Fornovo aad Borgo San Donnino. The cost of construction is estimated at about £253,240, and of provision of rolling stock about £18,788.

THE directors of the London and North-Western Railway have met the difficulties raised by the actuaries with regard to the company's superannuation fund by guaranteeing the benefits promised. In the next Bill powers will be taken to enable the company to carry out this arrangement, which will receive, we are sure. the hearty approval of the shareholders.

MR. JOHN MATHIESON, of Little Eaton House, Duffield, Derby, ex-general manager of the Midland Railway Company, who died at Harrogate on the 9th of August last, in his sixtieth year, appointed the widow, Mrs. Agnes Mathieson, of Little Eaton House. the sole executrix, by whom the estate is returned at £17,027, 6s. 6d. gross, and £16,607 7s. 10d. net.

ACCORDING to details of the railway estimates of Switzerland for 1907, the total expenditure under the heading of construction during that year is fixed at about £1,850,962, as compared with about £1,588,991 in 1906. The expenditure on the construction and improvement of lines, stations, &c., is fixed at about £1,168,804, while about £643,288 are assigned for the purchase of rolling stock.

THE *Gaceta de Madrid* of November 12th states that the Ministry of Fomento, Spain, have authorised the Murcia Electric Tramways Company to carry out surveys for the construction of secondary railways from Calasparra to Caravaca, Caravaca to Fortuna *viâ* Archena and Mula, Mula to Alcantarilla, Murcia to Crevillente, and Totana to Mazarron. The headquarters of the company are situated in Brussels.

THE new tunnel under Capitol Hill, Washington, between the Capitol and the Congressional Library, which the Pennsylvania Railroad Company has been building for southern connections, has been completed. It is 4033ft. long, and is composed of two single-track tubes, separated by a masonry wall. The new station into which all the trains entering the Capital City are to run will be one of the largest and finest in the United States.

A RAILWAY about 60 miles long will be built in the Sierra Madres of Western Mexico by Colonel W. C. Greene and associates. It will run from Temosachic, State of Chihuahua, to the timber lands of the Sierra Madre Land and Lumber Company. The construction will be paid for by an issue of £600,000 bonds on the lands and other property of the lumber company. The new railway will connect with the Chihuahua and Pacific Railroad at Temosachic.

THREE great groups of Russian railways are about to be formed by the fusion of several lines that are contiguous. Thus, the Baltic Railway, the St. Petersburg and Warsaw Railway, and the Pskoff and Riga line will form the north-western group, the Moscow, Yaroslav and Archangel, and the St. Petersburg and Viatka Railway will form the northern group, while the Koursk, Kharkov, and Sebastopol line, with that running between Kharkov and Nikolaieff, will form the southern group. This new scheme will come into force on January 14th (New Style), 1907.

THE Pennsylvania Railroad is about to build twenty-five freight engines which will be the largest and heaviest locomotives it has ever constructed or utilised for its regular freight service. The new engines, which will be experimental for the time, will be known as the H8 Consolidation type. They will have a heating surface of 3850 square feet; cylinders, 24in. by 28in.; the diameter of their driving wheels will be 62in , or 6in. more than the present standard; they will have a tractive power of 43,000 lb., and will weigh, in working order, over 100 tons.

WITH increasing taxation and municipal tramway competition, English railway companies are finding difficulties in showing a fair return for the capital invested in their enterprises. An American railroad has hit upon a novel device for attracting the public. The Long Island Railroad proposes to construct a sixty-mile "speedway" for automobilists. The construction of this track will be such that there will be no level crossing either of a road or railroad throughout its length. It will be fenced and probably have entrance gates five or ten miles apart. Its cost is estimated at £300,000.

THE Kali Sind bridge at Kakroada, about midway on the Baran-Kotah branch of the Nagda-Muttra Railway, will consist of eleven spans of 100ft., four spans of 150ft., and two land spans of 60ft. steel plate girders. According to *Indian Engineering*, the rails will be carried on the top boom for a single line, and there will not be a roadway for vehicular traffic. It is expected that this branch, which is forty miles long and will be a cross connection between the Indian Midland Railway and the Nagda-Muttra Railway, will be completed in another twelvemonth, and in advance of the main line, which latter may be opened through by May, 1908.

THE necessary steps are being taken to obtain parliamentary powers to construct a tunnel under the Thames, which will connect Greenhithe, on the South-Eastern and Chatham Railway, with Purfleet, on the London, Tilbury, and Southend system. Such a tunnel, together with the necessary equipment, sidings, and approaches, will, it is computed, cost between £700,000 and £800,000. The total length of the line would be four and a-half miles, of which a mile and a-half would be tunnel bored through chalk. Open cuttings and approaches would extend to about a mile and a-half on either side. The idea is to provide for electric haulage.

NOTES AND MEMORANDA.

IN an article on the "Effect of Altitude on Combustion," by Mr. C. M. Palmer in *Power*, the author shows that a furnace working at 7500ft. elevation will use 28 per cent. more fuel than one at sea-level, charge, percentage of coke, blast pressure, &c., being identical.

REGARDING the value of the exponent n in the expression $p v^n$ = constant, it has been recently pointed out that this value may safely be taken at 1·3 for the compression curve of a gas engine indicator diagram, and 1·35 for the expansion curve. This is quite at variance with the value 1·41, usually heret fore accepted for this exponent.

TO calculate the rate of flow of an artesian well a simple plan is to lower a bottle of aniline fluid to a depth of, say, 500ft., and then electrically explode a cap to burst the bottle. The time required for the fluid to appear at the surface gives an accurate gauge as to the velocity of flow. It is claimed that this method gives results as accurate as a weir. The diameter of the pipe being known, the rate of flow readily follows.

IT is stated that the premier copper-producing mine of Australia for 1906 will be Mount Lyell, with an output aggregating about 8500 tons of metal. Wallaroo and Moonta, South Australia, will be second, with a little over 6000 tons; Great Cobar, N.S.W., and Mount Morgan, Queensland, will each produce 4000 tons. The O.K. output will scarcely reach 2000 tons this year. These five mines will probably account for nearly 60 per cent. of the Australian copper production for 1906.

THE U.S. armoured cruiser California has had a successful four hours' trial run. The required speed was made, and the run was satisfactory in every way. No further difficulty was experienced with the machinery of the ship. The same board which conducted the trial of the California will give the South Dakota its trial in about a month's time. An unofficial account says that the vessel on her trial averaged 22·22 knots, and that her best time was 22·32 for fifteen minutes at a stretch.

IF no further deposits of anthracite coal are discovered in Pennsylvania, says the *Engineering and Mining Journal*, it is probable that the present supply will be completely mined in eighty years, allowing for a proportionate increase in tonnage based on collected data. The hope for new deposits lies not in the discovery of new unworked areas, but rather in the finding of seams at greater depths, and the profitable working of present seams that have hardly been considered commercially valuable.

AFTER a series of experiments lasting four years Professor Korn, of Munich University, claims to have succeeded in solving the problem of being able to photograph an object at a great distance. The apparatus used by the Professor enabled him to transmit a photographic *cliché*, either by telegraph wires or by telephone lines, an unlimited distance in twenty minutes. The latest experiments resulted in sending a portrait from Munich to St. Petersburg in six minutes, while from Munich to New York forty-five minutes would be needed. Professor Korn hopes to arrive at results even far more surprising.

ACCORDING to recent French statistics, the value of the rubber imported into the markets of the world during 1904 was about £28,000,000, which represented a total weight of 156,000,000 lb. Havre alone imported 12,348,000 lb., and Bordeaux took 2,600,400 lb. There was a great falling off in the quantity of rubber exported from the Congo Free State; in 1903 it exported 14,400,000 lb. of rubber, but in 1904 the export had fallen to 9,900,000 lb. On the other hand, the output of rubber in French Congo amounted to 2,400,000 lb., which was a considerable increase as compared with the production in 1903.

OF the common metals, sodium has the greatest conductivity per unit of weight. Comparing it with calcium, potassium, aluminium, and magnesium, which come next, it can also be the most cheaply prepared, and probably always will be, because the starting material is so cheap, stable, and pure, although potassium alone theoretically requires materially less energy for its production. In view of the high price of copper it is suggested by Mr. A. G. Betts, in the *Electrical World*, that sodium might be used as a substitute for electric conductors. Mr. Betts proposes to melt it and run it into iron tubes, forming a composite conductor.

TO obviate the expensive and slow method of copying illustrations and printed matter by photography a German inventor has suggested a simple expedient. He places upon a table the page or cut to be copied, and above it, at an angle of about 45 deg., is placed a mirror. The reflection of the copy in the mirror is focussed on the ground glass in the camera, but then, instead of using a plate, a smooth-faced bromide or negative paper is used for the exposure. The result is, of course, white letters or lines upon a black ground, but this is not usually objectionable. The use of the mirror is necessary to reverse the view, which would otherwise be inverted.

IT is stated that in the erection of the House of Representatives office building, adjacent to the United States Capitol at Washington, the first brick was laid at the site on the afternoon of July 5th, 1905, and on July 3rd, 1906, there had been laid in the walls 11,000 000 bricks. This is believed to be the greatest number of bricks laid in any building in one year in the United States, and probably in the world, says the *Scientific American*. One of the causes conducing to this record-breaking feat was the remarkably "open" winter of 1905-6. In those winter months the work continued almost without interruption from either snow or cold, and not more than twelve or fifteen days were lost during the entire winter by reason of weather conditions.

THEORETICALLY a miner working underground requires only 6¼ cubic feet of fresh air per minute for respiration, the absorption of moisture and the dilution of carbonic acid gas, says the *Engineering and Mining Journal*. This, however, assumes that all air after having been breathed is immediately removed without mixing with the surrounding atmosphere, a condition impossible to fulfil. Considering that the permissible vitiation of the air by the carbonic acid is six parts in 10,000, it will be found necessary to provide 66 cubic feet of air per minute to dilute and carry away the 0·8 cubic feet of carbonic acid produced per hour by one man. Considering the problem in this light, it is really evident that although an average man at work breathes only about 750 cubic inches of air per minute, the amount necessary to carry away the gases given off is the important consideration.

"THE Preservation of Surface Condenser Tubes" is the subject of a paper read by Mr. W. W. Churchill before the Amer. Assoc. for the Advancement of Science. The paper deals with corrosion due to salt water, and to water contaminated with chemicals or sewage. It was found that the cooling water contained impurities from the river, which led to rapid corrosion and destruction of the Cu-Zn alloy of which the condenser tubes were made, the action being intensified by the stray ground currents from the Brooklyn Rapid Transit Railroad. The condensers were, therefore, insulated from the stray currents by the use of insulated joints for all pipe connections, and also by lengths of glass-lined pipe. A counter e.m.f. of 0·60 volt was then provided to overcome the positive e.m.f. of 0·42 volt set up when the alloy of the condensing tubes was placed in the cooling water, this counter current being provided by a 3-kilowatt generating set with wiring and switchboard as for electro-plating work. The apparatus has now been in operation for a period of fourteen months and has worked satisfactorily, only ten tubes having been destroyed by electrolytic action.

MISCELLANEA.

THE directors of the Morecambe (Regent-road) West End Pier Company, Limited, have decided to make alterations and additions to this pier at an early date.

THE work of installing oil pipes to carry the oil from Baku to Batoum on the Black Sea is at an end, and the system was announced to be consecrated on November 28th, New Style.

THE Bridlington Town Council have under consideration the installation of new plant at the waterworks. It has not ye been decided whether a steam or electricity-driven plant shall be adopted.

IT is reported from Seoul that the Corean Government have decided to construct waterworks at Pingyang. The cost is to be defrayed from the proceeds of the Japanese loan of ten million yen recently concluded.

ACCORDING to the approximate traffic returns for October, the Manchester Ship Canal receipts last month amounted to £42,583, as compared with £39.206 in October last year. For the ten months the receipts have totalled £397,316, or £41,370 more than in the corresponding period last year.

THE Russian Ministry of Finance has abandoned its project of levying a tax on electricity, mainly owing to the fact that electric energy is taxed only in Italy and Spain, and also to the fact that the cost of controlling and checking the amount of electricity used is so great and complicated that it is not worth doing.

THE United Engineering Society building in New York City is now receiving its interior finish, and contracts for the furnishings and equipment are being carried out. The building will be open for inspection in December, but owing te some unexpected delays it will not be ready for use at that time, as had been hoped.

BY an Act—to amend the Patents Act of 1903—assented to on October 12th, the Australian Commissioner of Patents now has power vested in him to extend times and revive lapsed applications. He has also power to remedy lapses arising from errors in the Patent-office. The new Act was passed at the instigation of Mr. G. Townsend, the Commissioner, and has for its object the preservation of inventors' rights.

CONCURRENTLY with the widening of Dover Admiralty Pier and the building of an extensive marine station, sanctioned by the Dover Harbour Bill, there will be carried out the overcliff drive, connecting Dover with St. Margaret's Bay, a distance of about five miles. The chalk excavated from the cliffs to make the road will be used to reclaim land from the sea. Powers for the overcliff drive have been granted by the Board of Trade.

A SUM of £10,000 has been granted by the trustees of the late Mr. T. Graham Young to Glasgow Technical College, to assist in making provision for the teaching of dyeing and bleaching in connection with the chair of technical chemistry in the college, and also a sum of £850 for apparatus for the Young chair. Mr. Graham's father, the founder of the paraffin oil industry in Scotland, endowed a chair of physical chemistry in the institution with a gift of £10,000.

FIVE American cities in which the largest amounts of wood pavement are found, are in order, Indianapolis, New York, Minneapolis, Toledo, and Boston. Together, these cities have more creosoted wood pavement than all other cities in the United States combined. The total amount of this pavement in use in the United States at the end of the year 1905 was about 1,400,000 square yards, equivalent to nearly 80 miles of pavement on a street 30ft. wide.

AN experimental pavement has now been laid in the city of Minneapolis, as a co-operative undertaking between the city government and the Forest Service. The woods used were long leaf pine, Norway pine, tamarack, white birch, western larch, and Washington fir. All blocks were laid with the grain vertical, and were 4in. in depth, 4in. wide, and from 4in. to 10in. long. These blocks were impregnated with creosote, and laid upon a foundation of Portland cement concrete. Successive sections of the pavement were laid in different woods. Also the angles of the courses were varied, one being at right angles to the traffic, another at 45 deg., and a third between the two, or 67½ deg.

THE use of windmills for generating electricity has given favourable results in the tests for the Danish Government made at Askow by Professor La Cour. The four-wing wheel proves to be the best form. With such a wheel, having 15 square yards of surface, he obtained 2 horse-power from a wind of 20ft. per second, and 10 horse-power from a wind of 35ft. per second. As reserve power, when there is no wind, a small petrol motor has been more satisfactory and less expensive than a storage battery. According to the *Contract Journal*, the Askow plant cost about £950, including land, and the annual expense of operation is £33. It feeds 450 incandescent lamps, with some arc lamps and motors.

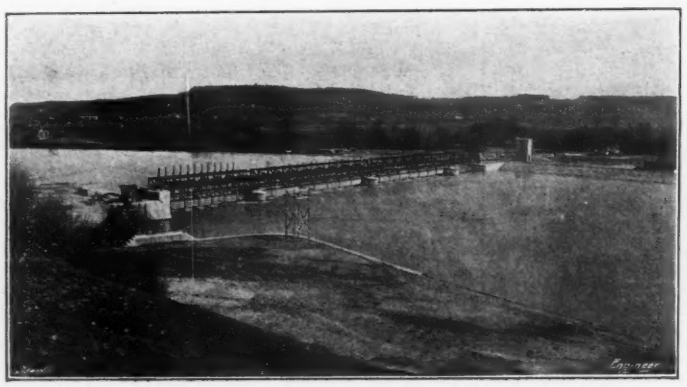
THE Motor Union have decided to make a grant to the Motor Van, Wagon, and Omnibus Users' Association for the purpose of testing the legality of the action of the Great Eastern Railway Company in putting up notices on a number of bridges over the Cambridge and Mildenhall line of the company, prohibiting heavy motor vehicles, of two tons and upwards in weight, from passing over them. The bridges have been inspected by a member of the Board of Advisory Engineers appointed by the Association, and from his report it would seem that they are strong enough to carry the weight of heavy motor traffic, but that they have been allowed to get into a state of disrepair. If the action of the railway company is upheld, it will mean the closing of a large tract of country to heavy motor vehicles.

THE new destroyers to be built in the coming year for the United States Navy are to be equipped with turbines, but it remains to be determined whether or not the vessels will have a speed above 30 knots, and on this point there is a difference of expert opinion, says the *Army and Navy Journal*. It is observed that the latest destroyers being built abroad all have a greater speed than 30 knots, while the British Admiralty has authorised several of 36 knots speed. It is understood that members of the naval General Board are inclined to view the 36-knot boats as purely experimental, and as approaching a quality not likely to be maintained. It is held that boats just as useful may be built with less speed, and it has been suggested that even a speed of 27 knots will suffice for all naval purposes.

FURTHER developments have taken place in connection with the scheme formulated for the construction of a masonry dam on the Goulburn River at Trawool, 63 miles from Melbourne. The scheme will, it is claimed, provide sufficient energy to supply all the motive power and lighting requirements of Melbourne, to run all the trams and electrify the whole of the suburban railways, with nearly enough over to run the mines of Ballarat and Bendigo. The price charged for electricity in Melbourne at the present time is 2d. per unit. The promoters of the Trawool scheme estimate that they will be able to transmit electrical energy within a radius of 100 miles of the generating station—a radius which includes the three cities mentioned—and supply it at a little less than ¾d. per unit. By a wall about 180ft. high from foundation to parapet about 70,000,000,000 cubic feet of water can be impounded, covering an area of some 25,000 acres, with an average depth of over 60ft.

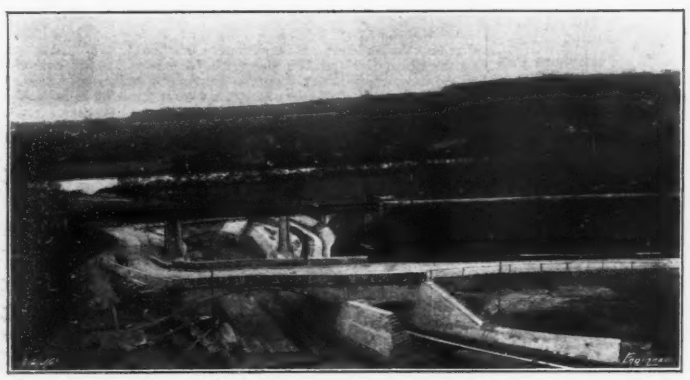
CONSTRUCTION OF THE WANGEN POWER STATION

(For description see page 544)

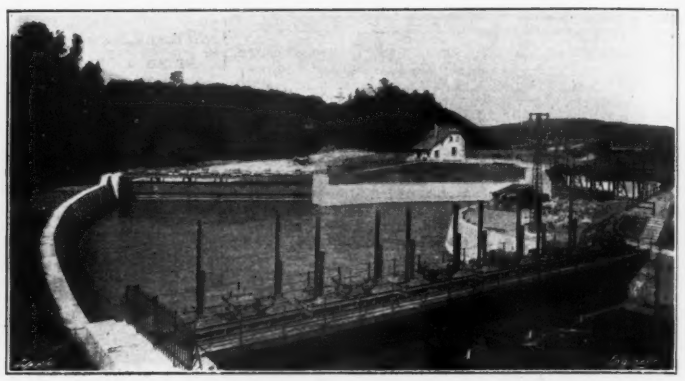


THE COMPLETE DAM

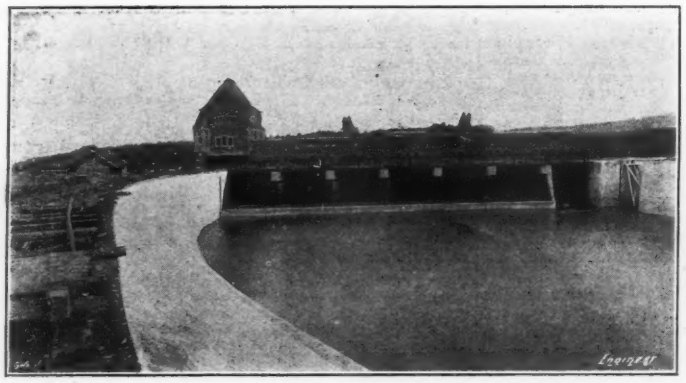
BUILDING THE WEIR



CANAL WORK UNDER THE BRIDGES

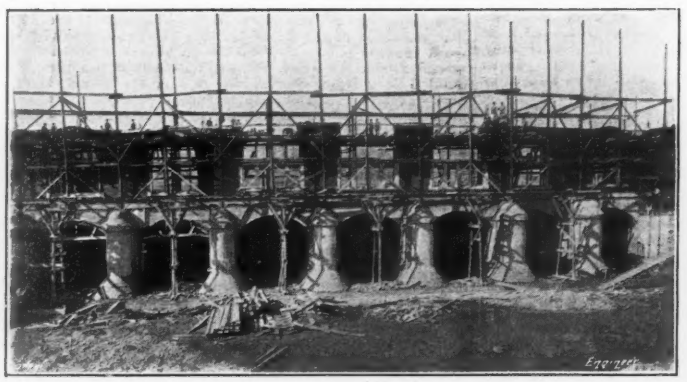


ENTRANCE TO THE CANAL

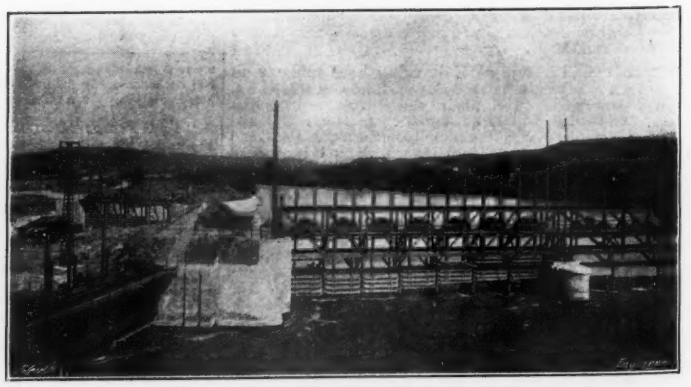


GENERAL VIEW OF POWER-HOUSE

ELECTRICAL EXCAVATOR AT WORK



DISCHARGING CHAMBERS



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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to intorm correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

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REPLIES.

P. T. (Stockport).—(1) It certainly would be advisable to have the feed-water analysed by a competent man. (2) There is no general rule for dealing with cases of the kind.

G. T.—The report on pipe flanges can be obtained from the offices of the Engineering Standards Committee, 28, Victoria-street, Westminster, or from the publishers, Crosby Lockwood and Co., Stationers' Hall-court, E.C.

INQUIRIES.

ROOFING FELT MAKING MACHINES.

Sir,—Can any of your readers inform me where I can obtain machines for manufacturing roofing felts? W. G. R.
November 27th.

OIL FURNACES FOR SMELTING.

Sir,—I shall be glad if you will give me the names of any firms that make oil furnaces for smelting purposes? C. P.
November 28th.

ERRATUM.

On page 517 of our last issue, "Fig. 35," in the seventh line from the bottom of the middle column, should read "Fig. 41."

MEETINGS NEXT WEEK.

The Tramways and Light Railways Association.—Tuesday, December 4th at 4 p.m., at the Westminster Palace Hotel. General meeting.

Institute of Marine Engineers.—Monday, December 3rd, at 8 p.m., at 58, Romford-road, Stratford, E. Paper, "Oil Engines for Marine Work," by Mr. F. Timpson.

Geologists' Association.—Friday, December 7th, at 8 p.m., at University College, Gower-street, W.C. Paper, "The Zones of the White Chalk of the English Coast," by Dr. Arthur W. Rowe, F.G.S. Illustrated by lantern slides.

Liverpool Engineering Society.—Wednesday, December 5th, at 8 p.m., at the Royal Institution, Colquitt-street. Ordinary meeting. Paper, "Graving Dock Construction, dealing with the New Brocklebank Graving Dock," by Mr. J. F. Ramsbotham.

Society of Engineers.—Monday, December 3rd, at 7.30 p.m., at the Royal United Service Institution, Whitehall. Ordinary meeting. Paper, "Prevention of the Bacterial Contamination of Streams and Oyster Beds," by W. Pollard Digby, F.S.S., A.M.I. Mech. E., A.M.I.E.E., and Henry C. H. Shenton, M.S.E.

The Institution of Electrical Engineers.—Thursday, December 6th, at 8 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Ordinary general meeting. Discussion, "Selection and Testing of Materials for Construction of Electric Machinery," by Professor J. Epstein.

The Institution of Civil Engineers.—Tuesday, December 4th, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Discussion on papers: "The Talla Water Supply of the Edinburgh and District Waterworks," by W. A. P. Tait, B.Sc., M. Inst C.E. "Repairing a Limestone Concrete Aqueduct," by M. Ratcliffe Barnett, M. Inst. C.E. "The Yield of Catchment-Areas," by E. P. Hill, M. Inst. C.E.

Society of Arts.—Monday, December 3rd, at 8 p.m., at John-street Adelphi, London, W.C. Cantor Lectures: "Artificial Fertilisers, their Nature and Functions," by A. D. Hall, M.A., Director of Lawes Agricultural Trust. Tuesday. December 4th, at 4.30 p.m. Colonial Section. "The Cape to Cairo Railway," by the Hon. Sir Lewis Mitchell, late Member of the Cape Ministry. Wednesday, December 5th, at 8 p.m. Ordinary meeting. "The Metric System," by Colonel Sir Charles M. Watson, K.C.M.G., C.B.

THE ENGINEER.

NOVEMBER 30, 1906.

Municipal Accounts.

One of the charges brought against the "Progressive" policy of municipal councils is that it is not only extravagant, but deceptive. Even those who are prepared to judge leniently are, it seems, compelled to admit that while real improvements are made and benefits conferred on the community, the distribution of the cost of these things is unfair, and, if not dishonest, at all events quite opposed to the principles and practice of sound finance. A notorious instance of this appears to be supplied by the tramway accounts of the London County Council, whose electrified lines recent investigations have shown are really worked at a loss, which is masked by manipulating the outlay on the widening of streets. But there is reason to believe that the London County Council does not stand alone, and that in various cities and municipalities losses are covered up, or even made to appear gains, by the simple process of arbitrarily distributing capital outlay and working expenses under carefully selected heads. To make the system intelligible, let us suppose that a man puts up an oak paling and makes a gravelled walk alongside it. The cost of the former is, say, £5, and of the latter £3, which is about twice too much. To hide the fact that he has made a mistake, he charges £6 10s. to the fence and £1 10s. to the gravelled walk. At first sight it might appear that an operation of this kind would be detected at once. But if the whole operation were carried out by various committees, and extended over some months, it would in all probability escape detection. It might even when found out, be excused in a multitude of ways; or after all be demonstrated that there was no cause for complaint because the total cost of walk and fence remained the same. No business man could be taken in by an argument so specious, for reasons which it is not, we think, necessary to point out.

Among recent onslaughts on municipal extravagance, a letter addressed by Mr. R. Stewart Bain to the Secretary of the Local Government Board, is not the least powerful. Mr. Bain is managing director of the London Electric Supply Corporation. His letter deals with the action of the electric lighting departments of the Boroughs of Bermondsey and of Southwark. He sets forth various complaints categorically. We shall confine our attention to only two or three, which possess special technical interest apart from finance. The first of Mr. Bain's accusations against the Bermondsey Council is "That the amount charged for public lighting is £3390 11s. 7d., viz., 361,662 Board of Trade units at 2¼d. My company made an offer to the borough on March 12th last to supply all the electric energy required for the public lamps in the borough at the rate of 1½d. per Board of Trade unit. On the above consumption this would amount to £2260 7s. 9d., or a saving of £1130 in the amount charged in the electricity accounts."

The first question that naturally suggests itself on reading this passage is twofold. In the first place, can the Electric Supply Corporation sell electricity at 1½d. per unit without incurring a loss; and in the second, if it can, why cannot the Bermondsey Council do likewise? If Mr. Bain works at a loss, then his competition is not legitimate. What the precise cost of production per unit is we are unable to say. That is, of course, the trade secret of his company. But it is no secret that it charges private consumers from 5d. to 7d. per unit according to circumstances, and it is quite possible that the working conditions are such that to sell for public lamps at 1½d. per unit and make a small profit is feasible. If this be the case, then it is quite clear that the taxpayer would be much better off in Mr. Bain's hands than in those of the Borough Council. It is unfortunate, to say the least, that the detailed expenses of the Bermondsey power-house, its cables, lamps, &c., are not made public.

The next charge made by Mr. Bain refers to a dust destructor. It is a curious and deplorable fact that the disposal of garbage has always been a subject of keen controversy and contradictory statements. We cannot call to mind any technical subject concerning which more quarrelling has taken place, arising, it is fair to add, in most cases, out of differences of opinion concerning the distribution of expenses and profits or losses. Thus, the destructor people claim so much profit for steam supplied to produce electricity; and the electrical men, on the other hand, assert that the charge is exorbitant. This, however, is only one phase of the dispute. There are, of course, other methods of disposing of refuse; and efficiency being the same in either case, then that which costs least ought to be adopted for the sake of the ratepayer. This is generally conceded. But the conflict then turns on "efficiency." Mr. Bain's second charge against the Bermondsey Council is, that whereas they got rid of their refuse for 2s. a ton—the cost of barging it out to sea before a destructor had been put up—now the cost is 5s. 7d. a ton. It appears that for the year ended March last the number of tons of dust dealt with was 19,607, at a cost of £6478. The revenue, including £580 charged to the electricity account for steam supplied, was £956. The actual cost, therefore, was £5522, or about 5s. 7d. per ton. "If this," writes Mr. Bain, "had been done before the erection of the electric station, the cost would have been £1960. The loss, therefore, for the year is £3562, the whole of which, although properly chargeable to the electricity account, has been carried to the general rate account." The only source of revenue besides steam appears to be slag. What was in the minds of the Council when they put up the destructor it is impossible to say. Apparently they must have altogether overrated the amount of the income to be derived from it. It is matter of common knowledge that, in so far as steam is concerned, the profit or loss with a destructor depends entirely on the characteristics of the "dust." It has been said with truth that it is a very difficult matter to make steam with old meat tins and new cabbage stalks. No one questions the merits of the Bermondsey destructor, yet it appears that the ratepayers would be better off without one.

Mr. Bain's third charge is, perhaps, the most important of all, because of the principle involved. In all sound finance a charge is made in some form for the depreciation of plant, and it should be made quite clear that this charge is sufficient for all legitimate contingencies. Obviously, it ought to be

deducted from revenue. What the amount should be is an open question, depending on what it is intended to cover. Thus, a very usual charge for the depreciation of boilers is 10 per cent. per annum on the original cost. The depreciation of a dynamo may well be very much less than this. The magnetic qualities of the machine do not deteriorate. The insulation may undergo some process of slow decay, but a moderate sum should suffice—unless, indeed, it is borne in mind that existing plant may have to be superseded by more modern machinery. However, it seems that thirteen of the London companies allow $1\frac{3}{4}$ per cent. per annum for depreciation. This sum is, we think, too small. Yet a great deal depends on what meaning is given to the word "depreciation." But be this as it may, it seems that neither the Bermondsey nor the Southwark electricity accounts contain any charge whatever for depreciation, and this although the power-house of the first has been at work for nearly five years, and that of the latter over seven. A private firm trading under such conditions must ultimately get into financial trouble. Why borough councils should expect to escape we cannot say. Possibly they look on the taxpayer as a valuable asset, from which they can always get money when they need it. The real question at issue admits of being very simply stated. Do councils trade on ordinary commercial methods, or do they not? We do not think we wrong anyone if we say that at most council tables will be found men who frankly admit that they wish to spend money on all manner of improvements whether the ratepayers do or do not wish for them, and they care nothing whether there is a profit or not. Mr. Burns and the Thames steamboats supply a case in point. Then there are men, mostly permanent officials, who hold that proper accounts ought to be kept; while others, being extremely bad financiers, and knowing practically nothing of the keeping of complicated accounts, muddle matters up, and unwittingly foster extravagance. We see what the result is. The cases stated by Mr. Bain are very far from being isolated. The ratepayer shows signs that he has at last began to wake up. He may not be able just yet to reduce expenditure; but he can at all events insist that municipal accounts shall be properly kept and open to him for inspection.

Patent Law Reform.

A LECTURE as admirable in substance as in form was delivered by Mr. J. W. Gordon at the Society of Arts on Wednesday evening. It reviewed the law of Patents for Invention of this country from the time of James I. to the present, and concluded with a discussion of some of the defects in it which now exist, and some means of correcting them. Of these defects the most important by far is that which gives to a foreigner a right to sell in this country goods manufactured in his own, and affords him the power of prohibiting their manufacture here. The anomaly of this condition of affairs is obvious on the briefest examination. The object of patent laws is to encourage the manufactures and trade of the country in which they obtain. That they should be employed for the very opposite purpose —that is actually to restrain a manufacture in this country for the benefit of a foreign country—is so manifest a perversion of the original intention that one cannot but wonder that it has been allowed to exist for thirty or forty years. Unfortunately, in the process of time, an issue which would have been very simple when it first arose has become, in the process of time, extremely complicated, and a return to the original intention cannot be made without raising powerful opposition.

When we are able to put before our readers the substance of Mr. Gordon's paper, it will be seen that he is in substantial agreement with such champions of reform as Sir Joseph Lawrence and Mr. Levinstein, and that he should admit the existence of a defect in our law on this crucial point is of the highest importance, for he has, of all men, devoted himself to a thorough and complete study of patent legislation. One or two quotations from his paper will make his position absoutely clear. Speaking of the compulsory license he says: "The argument is that it is the patentee's business to introduce his manufacture, and it is right that on him should be cast the burden of starting the business himself or of finding a licensee to start it for him. 'Therefore,' say the advocates of this measure, 'shift the burden from the applicant for a licence and turn the patentholder into an applicant for a licensee. That is the logic of the situation if patents are granted for the purpose of establishing new manufactures within the realm.' This contention appears to be broadly sound, but the principle is a little difficult of application." And, further, he says: "The requirement of compulsory working is, therefore, one which needs to be imposed with carefully-considered limitations; but, given a rule elastic enough and equitable in operation, there is no doubt that for certain mischiefs it would be a remedy. And there is no reason to suppose that such a rule cannot be framed."

It will thus be seen that so eminent an authority as Mr. Gordon practically agrees that the defect exists, and he sees no insurmountable difficulty in its removal. But he himself suggests a cure for the evil, very different from that of the Associated Chambers of Commerce, which, as is well known, are exerting their enormous influence to effect a change; for, whereas they wish to see compulsory working enforced under certain conditions, Mr. Gordon suggest the removal or restriction of the injunction, that valuable weapon by which the owner of a patent absolutely prevents its use by others than his licensees. That the injunction may be misused was shown by some admirable, if special, examples in the paper; but it must be admitted that, in spite of its defects, it has, in the ease with which it is employed, certain manifest advantages over the alternative suggestion that the patentee should be able only to claim damages or compensation for infringement. In discussing this point, Sir Joseph Lawrence remarked that there had recently come to his knowledge a case where, had a British patentee not been able to procure an injunction to restrain a foreign infringer, his trade would have been ruined and himself rendered bankrupt before he could prove the damage done him by the foreign manufacturer. It may be retorted that in the end he would get compensation. But whilst it is open to the gravest doubt that he could obtain compensation from a foreign source, it is certain that a budding industry might in this way be destroyed, and that the benefit to the country as a whole—which is by far more important than a single man's affairs—would be by so much injured. On these grounds both Mr. Levinstein and Sir Joseph Lawrence were opposed to Mr. Gordon's proposal and adhered to the system of compulsory working. Their suggestions, as spokesmen for the Associated Chambers of Commerce, of which a deputation representing the industry, finance, and labour of this country, one of the most influential deputations that has ever been drawn together, waited recently upon the President of the Board of Trade, are exceedingly simple. They propose that any patentee shall, *if he works his patent* in another country, be compelled to work it in this, unless he can prove to the satisfaction of the Board of Trade that conditions exist which prevent it from being worked here. Mr. Gordon had given, as an instance of the objection to compulsory working, two cases—first, that of electric incandescent lamps; and, secondly, that of the manufacture of nitrates from the nitrogen of the air. In the first case he showed that the original patent for incandescent lamps was rendered valueless by improvements invented by the patentee himself before ever it had been employed. Was then, he asked, the patentee, in order to keep his patent in force, to be obliged to work an obsolete method? To this the quite sufficient reply was that if he did not use this method abroad he was not compelled to use it here. The second difficulty suggested turned on the availability of water power, which could be found in foreign countries more abundantly than in Great Britain. To insist on the compulsory working here of a process which depended for its success on a cheap supply of electricity would be to compel the manufacturer to work at a prohibitive cost. Mr. Levinstein pointed out that the second part of the proposal of the Chamber of Commerce, namely, that the Board of Trade might remove the compulsory working clause in certain cases, fully met this difficulty. We may add that in such an exceptional case as this the desirability of granting a patent at all might be well questioned. Such a patent could only benefit one out of several foreign nations. It would give the right to one foreign firm to sell in this country and would exclude others. But that, we submit, is not the purpose of our patent law. Our law is to benefit our own country and our own dependencies and colonies, and that could be done in such a case as this by refusing a patent altogether, and permitting competition between foreign nations to lower the price to the British purchaser. It is, therefore, worth considering whether, in the very few instances where natural conditions do prevent the working of an invention in this country, a patent should not be wholly withheld.

It was extremely satisfactory to hear from Sir Joseph Lawrence that when the deputation had represented to Mr. Lloyd George that British manufacturers wished for the imposition of no restrictions on foreigners to which they themselves were not ready to submit, the President of the Board of Trade accepted their proposals, and promised to bring in a Bill embodying the suggested changes. Such a Bill has now been actually drafted, and it cannot fail to interest our readers to know that the admirable discussion on this subject which was carried on by Mr. Levinstein and Mr. Carpmael in our correspondence columns for many weeks in the spring of this year has helped materially in bringing about this result.

It is to be regretted that the limits of time prevented the conclusion of the discussion, and it is to be sincerely hoped that on its resumption early in the new year the opponents of change of the existing conditions may be heard.

The Iron and Steel Outlook.

THE period of prosperity which prevails in the iron and steel trades of the world has now been of such duration that the question arises as to whether the highest point has been reached and a downward movement already been commenced. In Great Britain the records of most of the iron and steel works for the past year indicate a decided improvement over the preceding twelve months, and the Board of Trade Returns show a considerable development in the export trade during the course of the present year. This situation of affairs, it is scarcely necessary to say, is not peculiar to the United Kingdom, as the producers of iron and steel in the United States, Germany, and Belgium are also enjoying the advantages resulting from the favourable course of business throughout the globe, notwithstanding the enormous inland consumption which obtains in two of the three countries in question. On the one hand, we find that the British exports of iron and steel in the first ten months of this year amounted to 690,000 tons in excess of the corresponding period of 1905. On the other, the exports from the United States in the first nine months were 310,000 tons greater than in the equivalent term of last year, and those from Germany increased by 380,000 tons in the same period respectively. Thus, by a remarkable coincidence, the combined gain of the United States and Germany in the nine months has been approximately the same in volume as for the ten months in the case of the United Kingdom; but when the figures are available for the other month, our two principal competitors will probably show to greater advantage. It is of importance to emphasise the fact that the export trade of the two countries concerned has not only been maintained, but also largely increased during a period of extraordinary activity in their home markets, which brought about an augmentation of 176,000 tons in the imports of iron and steel into Germany, and of 84,000 tons into the United States in the nine months, whereas the United Kingdom only purchased slightly over one thousand tons in the ten months in excess of the corresponding term of 1905.

It may be left to conjecture to suggest what the condition of the international iron and steel market might have been in the past year and a-half had it not been for the considerable expansion in the home demand of both the United States and Germany, because the great inland consumption of these two countries has tended to relieve the pressure of competition in other markets, especially in view of the increasing production of pig iron in both countries. Indeed, the output of pig iron in Germany in the first ten months, according to the returns of the Association of Iron and Steel Producers, amounted to 10,289,000 tons, or an increase of 1,320,000 tons over the equivalent term of 1905; and the augmentation in the case of the United States, as soon as trustworthy figures are available, will be considerably greater. Yet the Germans are unable to meet the demand for pig iron, and continue to purchase quantities from Great Britain, whilst the United States have also come forward as a large buyer in this country, to say nothing of the requisitions from Belgium for some time past. It is certainly fortunate for British producers, as well as for those in other countries, that the period of high prosperity has continued for so long; but the question is as to whether it will be of much longer duration. The outlook is maintained on a favourable basis at the present time in the United Kingdom, America, and Germany, but as the first-mentioned has receded to the third position as an iron and steel producer in recent years, the course of business is naturally dominated largely by the developments both in the United States and in Germany. For the present there is no real indication of any reaction either in the United States or in Germany in the near future, seeing that the producers of pig iron and steel are already engaged on orders which will last them for three or four months, if not for a slightly longer period; but it would be unwise to manifest too much confidence in a continuance of existing conditions over next year.

The British iron and steel market, it has to be

admitted, is largely affected by the current of affairs in Germany, and it is from that country that a note of warning is now being sounded. There, as in the United Kingdom, money is dear, and the restrictions of the money market are beginning to operate adversely to the development of industry. By a coincidence, the same factors in the situation were perceived at the beginning of 1900, and the third or fourth month of the year witnessed a severe collapse in all branches of the iron and steel industry. At the present time the prices of coal have reached the level of those obtaining in 1900, and the quotations for coke, pig iron, and semi-finished steel are not far from attaining that position. If we exclude the element of speculation, it is found that almost every feature which preceded the downfall of 1900-1901 is in evidence at the present time. Towards the end of 1899 the principals of certain iron and steel works declared that the height of prosperity had been passed, while, on the other hand, the optimists asserted that that stage had not been reached. Yet only a few months elapsed and the reaction was complete. Equally conflicting opinions prevail at the present moment. Dr. Paul Wachler goes so far as to state that in all probability the course of prosperity will extend beyond the year 1907. On the other hand, Herr August Thyssen, the iron king, expresses himself in favour of contracts of short duration, especially for iron and steel manufactures, in order that the risks thereby assumed by both buyers and sellers may be limited as far as possible. This carefully-worded opinion deserves attention, as it represents the idea that is growing in the sense that extreme caution is necessary in regard to future action. Already the high prices of coal, pig iron, and raw steel are being severely felt by the transforming works which do not also produce the raw materials. The fermentation proceeding among the coal miners is another cloud on the horizon, and to this has to be added the uncertainty surrounding the fate of the steel syndicate, whose agreement will nominally expire next June, and the continued dearness of money. All these circumstances tend to show the necessity for the exercise of extreme caution as to possible developments in the near future, and the outlook, can, therefore, not be regarded with full confidence.

Flash Boilers.

SOMETHING was heard at the meeting of the Institution of Mechanical Engineers, held on the 16th inst., about "flash" boilers. More may be heard to-night. In so far, however, as the term is applied to coil boilers, it appears to be a misnomer, to be retained, however, for convenience. It is assumed that the feed-water is suddenly converted into steam. But no one knows for certain that this takes place, and there is reason to think that it does not. The true flash boiler was quite a different affair. As made nearly half a century ago by the Reading Ironworks Company, it was neither more nor less than a closed cast iron pot or vessel of great thickness. This was kept red hot, outside at all events, by the furnace, and a measured quantity of water was injected forcibly against the bottom by a pump. The water sent in by each stroke of the pump was just enough in quantity to supply the engine with steam for one revolution. The experiment was unsatisfactory, and the flash boiler was abandoned. The so-called modern flash boiler, consisting of coils of tubing of small diameter, is a very old invention. It seems to have first acquired commercial importance in the hands of Mr. Herreshoff, who was, we believe, the first to put in feed-water at the top of a boiler and take steam out at the bottom. The peculiarity of the flash boiler appears to be that it is not supposed ever to have any water in it for more than a second or two at a time. The phenomena of steam-making under the conditions are very peculiar, but no one has given them much consideration.

We say here advisedly that dense ignorance exists not only concerning the nature of steam when made, but of the whole process of production. In the range of technical literature, English, French, and German, there is nothing more complete on the subject than half-a-dozen pages in Ganot's "Physics," and yet the subject is one of infinite interest. We at one time hoped that the electron theory would be used to solve various problems connected with steam, but so far nothing has come of it in this direction. We may take one of these problems, however, and consider it here. A tubular boiler of the Serpollet type has an exceedingly small water heating surface, as compared to that of other boilers; only a mere thread of water, so to speak, can be in the tubes. How does it happen that this small surface can make so much steam? The answer is that the temperature of the metal is very high, and that the efficiency of heating surface—that is to say, its steam-making powers—depends not on its amount alone, or on its temperature alone, but on the way in which water is brought into contact with it. There is good reason to believe that quiescent water is a bad steam maker, the rapid motion of water over a heating surface being of the utmost importance when much steam is needed. But there is no known "law" concerning this. We have the general facts, certain assumed truths based on them, and that is all. So far as knowledge extends, however, it may be said that there is no limit to the amount of heat which a plate can transmit so long as the side next the fire does not melt. It is all a question of keeping water in contact with the metal. If that condition could be secured on the one hand, and on the other a sufficiently hot fire, it is quite possible that as much as 100 lb. of steam per hour might be produced by one square foot of heating surface. No doubt the evaporative efficiency of the Serpollet, the White, and various other coil boilers is high; but the actual facts are masked by the circumstance that in all cases the steam is much superheated, and only general conclusions have been drawn. Indeed, the performance of flash boilers is, on the whole, so irregular that it is by no means easy to arrive at quantitative values of any kind with a fair approach to accuracy.

Two theories exist as to what takes place inside a highly heated tube of small diameter when water is pumped into it. One is, that the water being rapidly heated up, moves forward "solid" until a certain temperature is reached, and then "flashes" into steam, the action being very similar to that of a well-known lecture experiment with a eudiometer. At one instant a little glass tube is half-full of water; the next the water has entirely disappeared, and the tube is apparently empty. The other, and by far the more rational, theory is that the water is heated in one portion of the tube, boiled in another, and the resulting steam superheated in a third, no fixed line of demarcation ever existing. But there is no exact knowledge as to whereabouts the whole of the water has been converted into steam. No doubt this varies constantly, according to the temperatures and the demands made on the boiler. Two special features of the coil boiler are the tremendous pressures and the very high temperatures used. The former may reach 1000 lb. on the square inch; the superheat is so great that in an experimental omnibus now running in Scotland the cylinder covers work red-hot. The first entails the production of steam of small volume. At the pressure named 1 cubic foot of water becomes only 31 cubic feet of saturated steam, The temperature being 546·5 deg. Fah. At 250 lb. pressure, the temperature is 401 deg. Fah., while the volume is 114. The small volume is no doubt an important factor in securing success, if not an absolute essential, for reasons which cannot fail to be obvious.

The conditions under which the flash boiler is worked are inimical to its prolonged existence. If it were heated without access of free oxygen, it would not rust out, but the metal would none the less probably "lose its nature," and become brittle. It has long been known that in the much larger tubes of torpedo boat boilers only steel of a very fine quality can be got to stand. This is more than true of the coil boiler used for motor cars. It has been found, for example, that in the Serpollet boiler the lower tubes will bend down into the burner and obstruct it, unless they are made of nickel steel. Under ordinary conditions, the last thing an engineer wishes to see is a red-hot boiler; but the flash boiler depends for all its particular excellences on being kept red hot. Why it is that, under the circumstances, the water does not assume the spheroidal condition invariably, instead of sometimes, no one seems to know. Probably no one can know until a satisfactory theory of the spheroidal condition has been framed. That the water is kept dancing over a hot plate instead of coming into contact with it, by a layer of superheated steam is not a convincing statement. It is a pity that all the conditions cannot be reproduced in a glass boiler. The pressures and temperatures required put glass out of the question.

LITERATURE.

Time and Clocks: A Description of Ancient and Modern Methods of Measuring Time. By H. H. CUNYNGHAME, M.A., C.B., M.I.E.E. London: Archibald Constable and Co., Limited. 1906.

RECENTLY a change of some importance has taken place in technical literature. Formerly it was divided sharply enough into two classes—the popular and the scientific. The first gave more or less rudimentary information; the second was always abstruse, and now and then transcendental. One result of the sharp division was the spread of an idea that science could not be learned by those who did not understand algebra very well. It was not recognised that most of the principles of natural science can be easily enough mastered without any mathematical knowledge whatever beyond the rules of arithmetic and mental power sufficient for the appreciation of the fact that two and two make four. This was an insurmountable stumbling-block in the way of hundreds of engineering minds. Lately, however, highly competent men have undertaken to teach science almost entirely without the aid of algebra. Their books, on the one hand, are accurate, precise, instructive, and convincing in a way that no "popular" treatise can be; and, on the other, such pains have been taken to make, first, the facts of natural science known; and, secondly, to define their relationships and influence on each other, that any one possessing intelligence, and reading with care cannot fail to acquire sound information in most branches of science.

The small octavo volume before us is one of the latest examples of this literature, and it is one in all respects excellent. We endorse most heartily every word of the introduction. Take, for example, the following passage:—"The fatal practice of learning words without trying to obtain a clear comprehension of their meaning causes many teachers to use mathematical formulæ not as mere steps in a logical chain, but like magical cauldrons into which they put the premises, as the witches put herbs and babies' thumbs into their pots, and expect the answers to rise like apparitions by some occult process that they cannot explain."

Our author begins with definitions:—"All students of any subject are first apt to be perplexed with the number and complications of the new ideas presented to them." Keeping this in mind, he proceeds to explain the meaning of such words as "mass," "gravity," "space," &c. &c. It is well to add here that he does not try to explain what the thing is, but the sense in which the word denoting it is used. He keeps as clear as he is able of metaphysics; and having established a basis, he goes on to give the history in so far as it is known of the growth of ideas concerning time, and of the methods by which it is measured. The author's style is at all times excellent. He does not write down to the reader, but lifts the reader up to his own plane of thought. He explains the causes of change in the length of the day, the reason why chronometers are essential to navigation, and a multitude of subjects which appear at first sight—but only at first sight—to be but remotely connected with time and clocks. The skill with which he has avoided mathematic formulæ is remarkable. In no case, however, has he flinched from his purpose of making his subject intelligible. Thus, for example, it is known that pendulums are not isochronous, unless the centre of gravity describes not a circular but a cycloidal arc. His explanation of the reason why is most masterly. His story of the work of Galileo, Huygens, and others, to whom the world is indebted so deeply, never flags in interest.

Although he obviously understands clocks and watches, Mr. Cunynghame has not written a treatise on their construction; indeed, it is doubtful if he has ever mastered the details of practice by which alone the very highest accuracy can be obtained. Thus, for example, he takes it for granted that the oscillations of a balance controlled by a coiled spring will be isochronous—that is to say, no matter how great or how small the arc described, the time of oscillation will always be the same. But this result can only be obtained by distorting the ends of the balance spring from a true helix where they are secured to the "cock" of the watch at one end and to the "collet" on the balance staff at the other end. It is not too much to say that on this distortion will, in nine cases out of ten, depend the qualities of a ship's chronometer as a timekeeper. The curve cannot be calculated beforehand; it can only be arrived at experimentally for each chronometer by men who have devoted their lives to timing chronometers, and a dozen springs may be tried and rejected before the best result has been obtained. This is a curious scientific fact, and we are not aware that any adequate explanation of it has ever been given.

Mr. Cunynghame is discursive, yet we always feel that he has barely said enough. A perusal of the book cannot fail to enlarge our ideas. He throws new light on much, and he drags to the front facts and reasonings and theories which are often overlooked. We are glad to see that he has a good word to say for that really excellent timekeeper, the "grandfather" clock. Those who possess one, and have hitherto given little thought to it, will be surprised, we fancy, to hear how much from Mr. Cunynghame's pages it represents metaphysically, historically, and mechanically. Altogether, this is a delightful book. We congratulate the author and the publishers alike on its production.

BOOKS RECEIVED.

Treatise on the Law and Practice relating to Letters Patent for Inventions. Two vols. Third edition. By Robert Frost, B.Sc. (Lond.) London: Stevens and Haynes, Law Publishers, 13, Bell-yard, Temple Bar. Price 32s. net.

British Rainfall, 1905: On the Distribution of Rain in Space and Time over the British Isles during the Year 1905. By Hugh Robert Mill. London: Edward Stanford, 12, 13, and 14, Long-acre, W.C. Price 10s.

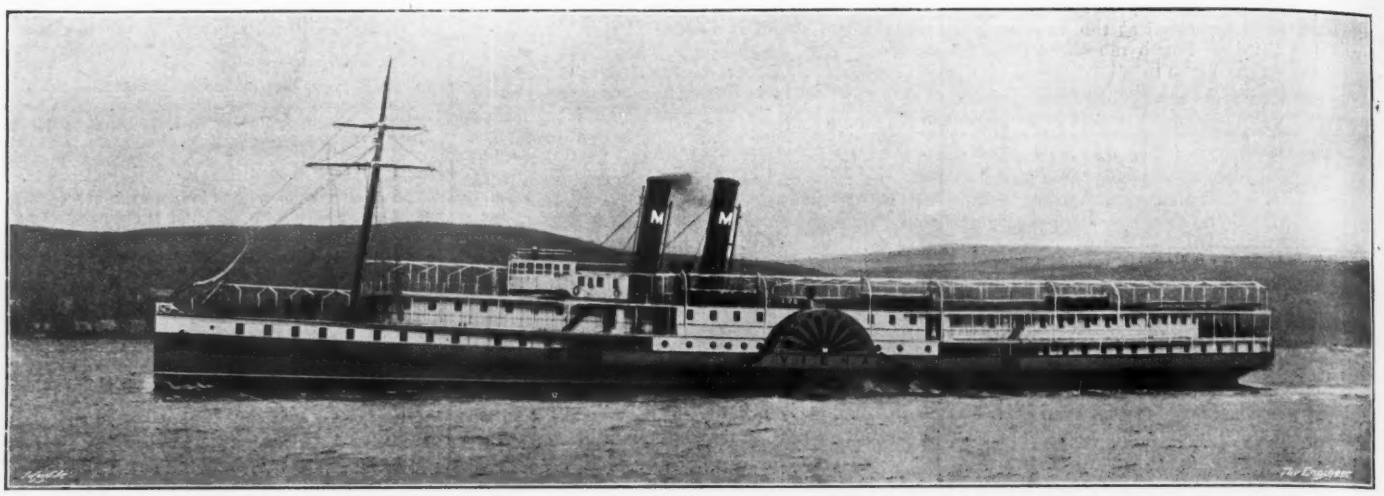
Fire Tests with Glass. Two Tests, each with Three Window Openings filled in with Wired Glass. By Mississippi Wire Glass Company, New York. London: The British Fire Prevention Committee, 1, Waterloo-place, Pall Mall. Price 2s. 6d.

The Theory of the Steam Turbine: A Treatise on the Principles of Construction of the Steam Turbine, with Historical Notes on its Development. By Alexander Jude. London: Charles Griffin and Co., Limited, Exeter-street, Strand, W.C. Price 15s. net.

Regulations Relating to the Royal College of Science; the Royal School of Mines; the Royal College of Art; and to Museums under the Board of Education (from August 1st, 1906, to 31st July, 1907). London: Wyman and Sons, Limited, Fetter-lane, E.C. Price 6d.

PADDLE STEAMER VIENA

A. AND J. INGLIS, POINTHOUSE, BUILDERS



BRIDGING THE RIVER LEE, CORK.

In the articles that appeared in THE ENGINEER of August 24th and September 21st last, on the subject of Irish railways, reference was made to the recommendations of the Allport Commission of 1886. One of the recommendations made by the Commission had reference to the want of through connections in the city of Cork. There are five separate companies in Cork which use five different stations, none of which have any intercommunication, whilst the rail connections to the river quays are meagre and indifferent.

The principal railway is the Great Southern and Western, and of the smaller companies the most important is the Cork, Bandon and South Coast. This road is nearly a hundred miles in length, and serves a country very rich in fishing and agriculture. The Great Southern and Western lines are all on the north side of the river Lee, and the Cork, Bandon and South Coast is on the south side. This want of through communication interferes to a serious extent with the transit of fish and other commodities from off the Bandon line, causing a loss of time and increased cost of carriage. An idea of this inconvenience may be gathered from the evidence given before the Allport Commission by Mr. Alexander Gordon, formerly general manager of the Bandon line. He said:—"The . . . connection at Cork with the Great Southern and Western Railway by a bridge across the Lee would stimulate a new industry for which at present there is no outlet, viz., the growing of early vegetables—potatoes, tomatoes, &c. Our climate is better suited for the growth of such vegetables than even the South of England, and the large prices obtained by the market gardeners of Cornwall in London would induce many in our South Coast to start the growing of such remunerative early crops if there were proper facilities for quick transit to London, and here the wonderful supply of coral sand to be found in the neighbourhood would be of the greatest help. It—the connection—would assist in abolishing a very objectionable toll which is levied by the Corporation of Cork on goods passing through the city. This toll is very injurious to trade in Cork. As an instance, Bandon was some years ago famous for its tanning establishments. Leather made in Bandon was celebrated for its superior quality, which was supposed to be derived from some peculiarity in the water of the Bandon River. The Bandon tanners had generally to get the raw hides through Cork, when a toll of 1d. per hide was levied by the Cork Corporation. When the hides were made into leather and sent to the leather merchants a further toll of 1d. per hide was levied by the Corporation on the leather entering Cork. One hundred hides of leather would be carried from Bandon to Cork by rail for 4s. 10d., while tolls amounting to 16s. 8d. would be paid to the Corporation of Cork on the same consignment."

In their report the Allport Commission said on this subject: "Owing to this break—the absence of a physical connection at Cork—the cost of carriage from the important and growing district of south-west Cork, and the injury to the fish by delay and transhipment, are much increased, the cost of cartage alone through the city being 2s. per ton."

Nearly a decade has elapsed since these recommendations were made, but the conditions have not been altered. A project is now, however, within reasonable distance of being carried into effect. Three schemes came before the parliamentary committees in May last. The first proposes to establish a connection with the Cork and Macroom Railway, and the Cork, Bandon and South Coast. As proposed, the new line was to branch off from the latter in a westerly direction near Southern-road, and be carried at a high level above Anglesea-street, across the Parnell Bridge—already a swing bridge—along Parnell-place, and by a new high fixed bridge over the Lee, whence it was to curve in an easterly direction and join the Great Southern and Western terminus (A). A spur line gave a connection to the Albert Quay and another to the Cork, Blackrock and Passage Railway.

NEW RAILWAY CONNECTIONS IN CORK

The second scheme proposed to leave the Bandon line near the gasworks, pass to the east side of the Bandon station, cross the south channel and the north channel by a two-deck bridge, and thence run to the Great Southern and Western station.

It was generally admitted that the first-named scheme was a very good one, but too costly. The third scheme, which was the cheapest, and the one eventually approved, is shown in the map published herewith. It had the support of the Cork and Bandon Company; the Great Southern, and the Great Western, of England. It also had the approval of the Cork Corporation and the Harbour Board. The new line will leave the existing Bandon railway at a point south of Gasworks-road, and pass between the present railway and Eglington street to the existing Bandon terminus (B), which will be altered to accommodate the new line. Spanning the south channel between Albert Quay and Lapps' Quay will be a new bridge, 60ft. wide, and over the north channel will be another bridge of the same width. Between these bridges, and from the north bridge to the foot of Summer Hill, will be constructed a fine thoroughfare, which will form an imposing street from the Bandon terminus to Summer Hill. The line will be low level, the same level as the quays, &c., and will run in the centre of the new thoroughfare, leaving the remaining width available for ordinary road traffic. The bridges are to be of bascule type, and constructed for a single line of railway. From the foot of Summer Hill the new line will curve in an easterly direction and enter the existing Great Southern Station.

The quays at Cork are very deficient in railway facilities, but this is to be remedied in the new scheme, as access is to be given from the new line to both sides of the promontory on which the Custom House stands, also to the north side of the North Channel. It is also proposed to extend the existing Bandon lines on to the Victoria Wharf, and so give access to the deep water berths at the south jetty. The former will improve the rail connections for the City of Cork Steam Packet boats, and those of the Clyde Shipping Company, whilst the latter will enable the railways to increase their corn traffic. Another good feature of the scheme is the abolition of the road level crossing at Gasworks-road, as this road is to be closed and the traffic diverted on to a new bridge to be erected. The parliamentary estimate was roughly £100,000, of which the Treasury have agreed to provide £25,000, the Cork, Bandon, and South Coast have made themselves responsible for £15,000, and the Cork Harbour Board for £10,000; whilst the Great Western—of England—have undertaken to see the scheme through.

We are indebted to Mr. J. R. Kerr, the general manager and engineer of the Cork and Bandon Railway, for the map herewith published, and for many of the items contained herein.

PASSENGER PADDLE STEAMER VIENA.

From several of the Clyde shipyards during the past six months a number of steamers and sailing vessels have been turned out, all to the order of the Navegacion a Vapor Nicolas Mihanovich of Buenos Aires, and possessing special features appropriate to the South American service for which they are intended. This shipping company, of which Senor N. Mihanovich, a native of Trieste, is president, already owns a fleet of about sixty vessels all told, and this is being augmented at the present time by three steamers and five sailing vessels, all built in Clyde yards.

The largest, handsomest, and fastest of the steamers now being added to—and, indeed, the largest of—the Mihanovich fleet is the paddle steamer Viena, which A. and J. Inglis, of Pointhouse, have built and engined, and quite recently put through satisfactory trials for speed. Through the courtesy of the firm named we are able to reproduce, from a photograph taken by Mr. William Robertson, of Gourock, a view of the Viena as she appeared on the occasion of her speed trial on the Firth of Clyde on 16th ult.

The Viena's hull proper is built of steel, of scantlings securing requisite strength with the minimum of weight, but, as in other vessels of her type well known to passengers on American, South American, Chinese, and Indian rivers, a superstructure of timber decks and deck-houses forms the most imposing part of the vessel. Messrs. Inglis have had for many years special experience in this class of production, having turned out some of the earliest and most notable "floating palaces" for passenger traffic on Chinese and South American rivers. In the case of a few of the former the tiers of promenade and awning decks, the many windowed deck-houses, the broad sponsons, together with the "hogging" framework, the "walking beam" of the propelling engine, and the massive paddle-boxes were unusual and striking features which always created comment. In designing and producing the Viena the Inglis firm has improved upon former successes, and in the Viena the Buenos Aireans shipowners are to be congratulated on possessing a vessel in every way admirably suited to the service intended.

The Viena's dimensions are:—Length, 330ft.; breadth, extreme over sponsons, 72ft.; depth, 31ft.; and gross register, 2700 tons. The accommodation for 400 first and a large

number of second-class passengers is distributed over three decks, the upper of these being admirably clear and sheltered for promenading purposes. Roominess, great airiness, and elegance characterise the accommodation and appointments. The lighting and ventilation throughout, both natural and artificial, are features which have been most carefully devised and carried out.

The illustration we give shows the Viena proceeding at a moderate speed in cold and blustering weather, and often in very rough water. Notwithstanding the boisterous winds prevailing—in encountering which, as will readily be understood, the vessel and her propelling agents had their own work cut out for them, owing to the large and uneven surface presented by the deck superstructures—the speed attained was a mean of 16½ knots, a performance considerably over the guarantee, which, in the circumstances as to wind and wind-surface, must be considered a very fair result. In passing, it may be stated that the vessel, when light, will float 8in. lighter than had been stipulated for, or permitted, by the owners; and the higher speed, conjoined to the shallower draught with the full load, thus forms an enhanced advantage. The engines of the vessel, which are of the diagonal triple-expansion type, were made by the builders at their engine and boiler works in Warroch-street, Glasgow.

Two smaller steamers, and three of the five sailing vessels being added to the Mihanovich fleet, have been built by William Denny and Brothers, Dumbarton, while the remaining two sailing vessels have been produced by Murdoch and Murray, Port Glasgow. The sailing vessels built at Dumbarton are three-masted square topsail schooners, 215ft. in length, 38ft. in breadth, 11ft. 6in. in depth, and designed to carry a considerable dead-weight on limited draught. The accommodation for officers and crew is in roomy deck-houses which are particularly suitable for the warm climate in which the vessels will principally serve. A feature somewhat unusual in sailing ships is a navigating bridge fitted across the roof of one of the deck houses, from which the vessels will be steered and controlled as in the case of steamers. For river navigation this arrangement has been found by the owners to be specially suitable.

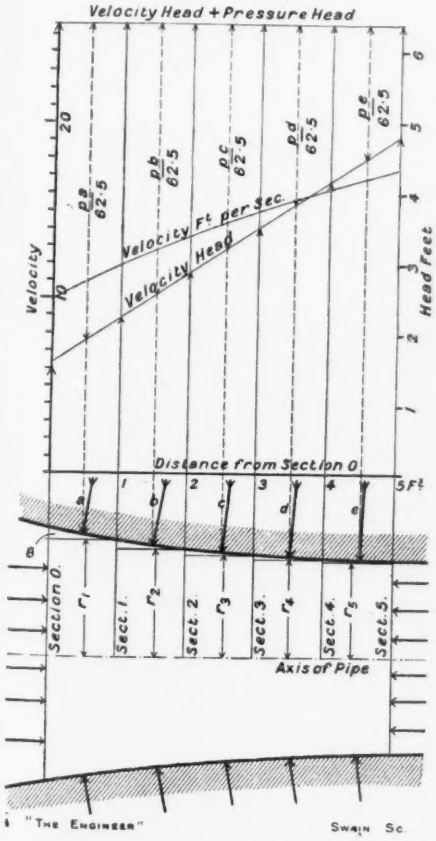
LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

VELOCITY OF WATER THROUGH A CONTRACTED PIPE.

Sir,—In your issue of October 19th an explanation was given, in an article on "Silt and Scour," of the increase of velocity at the throat of a contracted pipe. If the pipe is to run full, then the velocity of the water at the throat must, of necessity, be greater than that at the larger sections.

In the following investigation I have endeavoured to show, for one special case, that the excess of pressure at the large part of the pipe over that at the throat—obtained from Bernoulli's theorem—



supplies the force demanded by Newton's second law, to accelerate the mass of water.

The case considered is that in which the acceleration is constant between two sections 5ft. apart.

Let f = acceleration (constant) = $20\ \frac{\text{ft.}}{\text{sec.}^2}$

Q = flow = 100 cub ft. per second.

p_0 = pressure at sect. O = $300\ \frac{\text{lb.}}{\square\ \text{ft.}}$

v = velocity at section O (see Fig.) $\frac{\text{feet}}{\text{sec.}}$ = 10.

s = distance from section O to any other section (variable) in feet.

a = area of any section (variable) sq. ft.

v = velocity at any section (variable) ft./sec.

Then

$$v^2 = u^2 + 2\ fs$$

$$\therefore \frac{Q}{a} = \sqrt{u^2 + 2fs} \text{ since } \frac{Q}{a} = v \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\therefore a = \sqrt{\frac{Q^2}{u^2 + 2fs}} = \sqrt{\frac{100^2}{10^2 + 2 \times 20 \times s}} \quad . \quad . \quad (2)$$

From these equations (1) and (2), values of a, v, and the radius of the pipe have been calculated for various values of s—

s feet.	a sq. ft.	Vel. ft./sec.	Radius of pipe	$v^2/2g$
				ft.
0	10	10	1·785	1·59
1	8·45	11·84	1·641	2·23
2	7·45	13·38	1·540	2·83
3	6·74	14·85	1·466	3·51
4	6·20	16·12	1·405	4·14
5	5·78	17·30	1·357	4·76

The velocity head = $\frac{v^2}{2g}$ has also been tabulated—

Velocity head at section O = ... 1·59ft.

Pressure head at section O = $\frac{p_0}{32·5} = \frac{300}{62·5}$ = 4·80ft.

Total head ... ... 6·39ft.

By Bernoulli's theorem this must also be the total head at any section, such as sect. 5 for example.

$\therefore$ pressure head at section 5 = 6·39 − velocity head
= 6·39 − 4·76
= 1·63

$\therefore$ pressure at section 5 = $62·5 \times 1·63 = 102\ \frac{\text{lb.}}{\square\ \text{ft.}}$

Now the forces acting to produce acceleration of the mass of water between sections O and 5 are—

(1) 300 lb./□ ft. acting on section O
(2) 102 ,, ,, ,, 5
(3) The axial component of the pressure on the sides of the contracting pipe.

The latter can be dealt with approximately by considering the sides of the pipe to be straight between the sections, and treating the pipe as a series of truncated cones (see Fig.)

For example, the axial pressure due to the water pressure on cone a = total pressure on cone × sin. θ.

= $p_a \times \pi\ (r_0 + r_1)\ (r_0 - r_1)$ (approx.), since the distance between the sections = unity.

These values are tabulated below—

Cone.	p_a &c.	$(r_0^2 - r_1^2)$ &c.	Axial pressure, lb.
	lb./□ in.		
a	280	·50	440
b	241	·32	242
c	200	·22	138
d	161	·18	91
e	120	·13	49
		Total axial force ..	960

* Scaled off diagram.

$\therefore$ total force causing acceleration
= 300 × 10 − 102 × 5·78 − 960
= 300 − 590 − 960 = 1450 lb.

The volume of water between sections (1) and (5) = 37·18 cu. ft., hence the weight = 37·18 × 62·5.

Therefore by Newton's second law the acceleration should be—

$\frac{1450 \times 32·2}{37·18 \times 62·5} = 20·07\ \frac{\text{ft.}}{\text{sec.}^2}$, which is nearly the value taken.

Hence the laws of Bernoulli and Newton are in harmony.

HERBERT PURDAY.

Beckenham, Kent, November 3rd.

UNDERGROUND SURVEYS.

Sir,—The importance of the accurate connection of underground and surface surveys has long been recognised in relation to collieries, but the enormous growth in recent years of tunnelling for "tubes" and other purposes has resulted in the need for still more accurate methods than those hitherto employed.

Difficulty in determining this connection does not as a rule arise except in cases where only one shaft connects the underground workings with the surface.

The first fairly accurate method employed was devised by Mr. A. Beanlands about 1857. This method consisted in observing, with a transit instrument placed at the top of the shaft, two marks at the bottom of the shaft. Later, two marks have been set out at the top of the shaft by the use of a transit instrument placed at the bottom. In driving the Severn Tunnel Mr. Richardson devised a method which, whilst displaying great ingenuity, was hardly susceptible of any greater degree of accuracy than the older methods; he substituted for the two marks used by Beaulands a portion of a stretched wire.

For a full description of these methods the reader is referred to "A Treatise on Mine Surveying," by Bennett H. Brough.

In all these methods the degree of accuracy attained depends upon the accuracy with which the marks are set out and "picked up," and as the marks are of necessity only a few feet apart, any

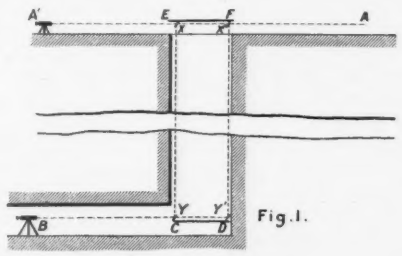


Fig. 1.

error is, if the workings are at all extensive, of grave importance. For example, an error of 0·05in. in the setting out and "picking up" of marks 10ft. apart will cause an error of 26·4in. at a distance of one mile.

These considerations have led the author to devise a method which, while being simple in practice, he believes to be susceptible of almost perfect accuracy, due to the abolition of physical marks and the substitution of an entirely optical method.

This method consists in observing a mark fixed at A—see Fig. 1.—or A^1 above ground by means of a level, or in the case of an inclined heading by a theodolite, fixed at B in the heading as far as possible from the bottom of the shaft by means of two inclined mirrors X and Y. The mirrors at X and Y are mounted so as to slide along two straight edges C D and E F to the positions X^1, Y^1. The mirror at X (X^1) is placed vertically over the mirror at Y (Y^1).

If the mark at A or A^1 lies upon the cross wires of the level at B when the mirrors are at X and Y and again with the mirrors at X^1 and Y^1, then A X Y B and A X^1 Y^1 B lie in one plane which is, provided X is vertically above Y, a vertical plane.

To carry this method out practically it is essential that the two straight edges shall be accurate and that the axes of rotation of the two mirrors shall be perpendicular to the straight edges.

The mirrors, made of speculum metal and truly polished, not larger than 1in. by 1½in., are mounted in a frame on trunnions similarly to a transit theodolite, and the frame base is fitted to slide upon the straight edge.

The adjustment of the mirrors to satisfy the condition already referred to is most easily performed above ground in the following manner:—A level is set up at L—Fig. 2—and the straight edge C D fixed upon a stand at some distance, so that the axis of rotation of the mirror is vertical, and so that the centre of the mirror remains in the axis of collimation when moved along the straight edge. The mirror is turned perpendicular to the straight edge, and adjusted till the image of the object glass of the level observed by reflection occupies the centre of the field of view when the mirror is

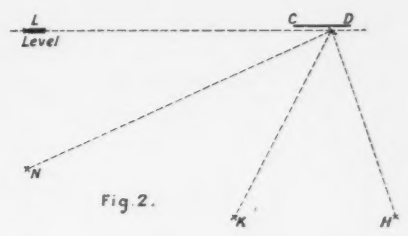


Fig. 2.

moved along the straight edge. When this adjustment is perfect it is obvious that the mirror lies in a plane truly perpendicular to the axis of collimation, but its axis of rotation may not be perpendicular to a plane passing through the straight edge, and the axis of rotation may not be parallel to the plane of the mirror. Two or three marks are now set up at H, K, N, so that they lie in the axis of collimation of the level when rotated to observe them. These marks are now observed by reflection in the mirror, which is rotated on its axis for this purpose, and the mirror axis is adjusted till these marks lie on the cross wires, whether observed directly or by reflection.

The mirrors may also be adjusted by means of transit observations of stars at various altitudes observed through a level by reflection.

In carrying out this method of connecting an underground survey with that of the surface, a level is set up at B in the heading at a considerable distance from the shaft, and one of the straight edges, placed at the bottom of the shaft, is adjusted as already described, so that the image of the object glass of the level occupies the centre of the field of view. The second straight edge E F is then supported over the top of the shaft as nearly as possible parallel with and vertically above C D.

This adjustment is easily tested by rotating the mirror Y to an angle of 45 deg., and the mirror X till parallel with E F; if the adjustment is perfect the image of the object glass of the level—which must, of course, be illuminated—will still be observed by reflection once in X and twice in Y; the adjustment is then tested with the mirrors at X^1 and Y^1. A level is then set up in the line $X X^1$ at A or A^1, and the mirror X rotated till the image of the level at A is observed in the level at B with the mirrors both at X Y and at X^1 and Y^1. The axis of collimation of the level at A is now parallel to that of the level at B, and in the same vertical plane, and a permanent mark may be put in at A or A^1.

The only error to which this method, when carefully carried out, appears liable is a want of verticality of the plane containing A, X, X^1, Y Y^1 B. This error is common to all the methods described, and, in the author's method, can only occur if the axes of both mirrors are inclined at the same angle to the horizontal, and the straight edge E F so displaced sideways that a line joining the centres of the mirrors is perpendicular to these axes—a set of circumstances which can hardly occur. The error is, in any case, very small, and does not increase as the distances of A and B from the shaft are increased.

November 20th. A. B. CHATWOOD.

LLOYD'S ANNUAL REPORTS.

Sir,—The annual reports of Lloyd's Register are undoubtedly interesting and valuable, but both qualities could be increased were the Statistical Department to provide a little more of the information which is at its disposal. Let us take the report last issued as an example. It showed that at June 30th 10,065 merchant vessels, of 19 million tons gross, held the Society's class. Why should not the position a year ago also have been shown? Similarly, while we are given the number and tonnage of new vessels classed during the previous twelve months, nothing is stated showing how this compared with the progress made in the preceding year. We have to turn to private records to learn that the number classed in the twelve months ended June 30th, 1905, was 616. Taking steam tonnage alone, the numbers increased from 587 to 652, and their tonnage from 1,189,769 to 1,408,579. It will be observed that, whilst the totals increased, the tonnage per hull decreased 1000 tons. Does this mark any special development? The report contains no information on the point.

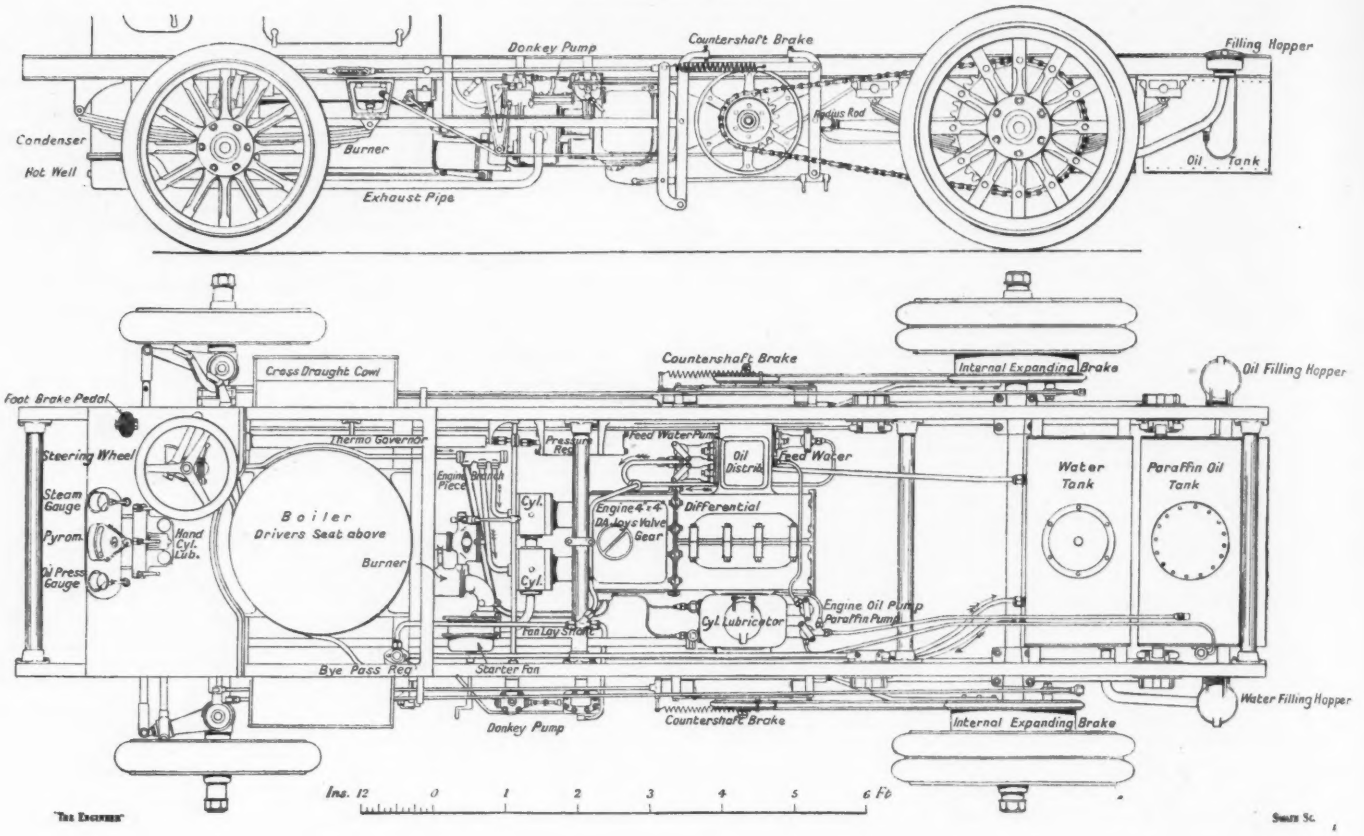
A paragraph devoted to "Special Types of Steamers" contains the statement that "the new vessels classed during the year under review include many of special types, designed to meet the requirements of the particular trades in which they are intended to be engaged." One would like to know how the individual types are progressing. Information on this point would surely be of wider importance than that "the rules of the Society admit of the highest class being assigned to vessels of all types, so long as the standard of strength is satisfactorily maintained." That is usually expected, is it not?

We are told of thirty-nine steamers, of over 5000 tons each, being classed, and nine of the largest are named. All these are liners. Why should the tramp be ignored? Some information concerning the tendency in her size would be of value. Turbine steamers are given a page to themselves, with a list of all vessels so propelled now holding the Society's classification. There are fourteen of them, and we are informed of their tonnage; but why not of their horse-power? That, one would imagine, is of some little importance.

The page dealing with the touring of the visiting Committee is not without interest. One is informed that during the Committee's visit to the Clyde district they were everywhere received most cordially, and were "greatly interested in the evidence of technical and scientific progress met with." This is satisfactory, but might not the satisfaction have been greater had the report contained something definite about the evidence of technical and scientific progress which so impressed the visitors? All there is in this regard is a note about a gas engine for marine propulsion. This was prominently brought to the notice of the Committee in connection with a set of engines "intended to be fitted in a vessel to be classed" with the Society. Why this reticence? Why should the Beardmore proposition be hidden under a bushel whilst the Parsons light is so well displayed? Perhaps it would be too much to expect

CHELMSFORD STEAM OMNIBUS

(For description see page 559)



praise at this early stage, but surely a little gracious nod might have been vouchsafed.

Taken as a whole, the report goes too far or it does not go far enough. If it is intended to give a report of the year's doings of the Society then it should be a full report, not a selection of features, or what may be considered such by the compilers. It ought to be a valuable work of reference.

November 20th. FENCHURCH.

THE PROPORTION OF LOCOMOTIVE CYLINDERS.

SIR,—The leader in your issue of 21st September regarding the proportion of locomotive cylinders was of such great interest that I had hoped some one with a more able pen would deal with this question, and place before your readers the true explanation of the anomalous conditions which exist with all types of engines.

As 1 lb. weight of steam should be able to exert as much power in one type of engine as another, it appears evident that the anomaly need not be looked for in the design of engine. It may be therefore generally accepted that when equal work is done by different engines, a practically equal weight of steam has been used in each case, and that any economy was due to the better quality of steam used in the engine giving the more economical results.

It must be obvious that the smaller compound engine was able to use the same weight of steam as the larger one by cutting off late in the high-pressure cylinders. We find the same experience with simple engines. For instance, an engine having 17in. cylinders will compete favourably against one having 18in. or even larger cylinders. Again, the modern engine, with 21in. cylinders, is known to do better work when the cylinders are bushed down to 19½in., the later cut-off in the latter case causing a better draught, and so enhancing the steaming power of the boiler. It is only the use of abnormally large boilers which makes it practicable for the larger-cylinder engine to develop greater power than the smaller one. On the other hand, the extra power can only be attained with an enhanced consumption of steam, and consequent extra expenditure in fuel consumption.

It is a trite saying in locomotive practice that the boiler is the measure of power in a locomotive. It would, in my opinion, be an equally true saying to add that it should also be the measure of economy, as from the use of steam of the highest quality only does it become practicable to get economical results.

It is, in my opinion, the general use of an absurdly low grade of steam in engineering practice which explains not only why it becomes possible for the smaller engine to equal the larger one, but also why it is that the simple engine can practically all round hold its own in competition against a compound one; it accounts for every anomalous condition in locomotive practice.

It may be argued that superheating the steam to improve its quality is largely carried out, and that it leads to considerable economy. The question may then be asked why it is that a mixture of water and steam is permissible in present-day practice. A short time ago I had occasion to take diagrams from a compound engine, with a boiler pressure of 100 lb., and failed to get decent diagrams from the low-pressure cylinder, due to the large quantity of water in the steam. The general belief is that for compounding a high boiler pressure is necessary, so as to secure dry steam. If it is admitted that some measure of economy is effected, due to increase in boiler pressure giving dry steam, and if by still further superheating this steam economy is still further enhanced, it may well be asked why engineers do not adopt a standard of steam temperature, so that steam users may realise that economy which appears to be the goal all engineers are endeavouring to reach, and which, curiously enough, can be had irrespective of pressure.

The standard of temperature might be something like 1000 deg. To make a distinction between the low grade of steam now in general use—including the so-called superheated steam—and the steam which should be in general use if the maximum of economy is to be attained, it would be advisable to make use of the term "steam gas." Steam users would then know that when ordering plant to generate and make use of steam gas they would realise from it the maximum of power combined with economy. Gas engine makers will tell you that steam is dying fast; it only remains for steam users to kill and bury it as early as possible by ordering plant which will generate and make use of steam gas. It must be obvious that a gas which can with safety be stored up and used at a pressure of 1000 lb. in its expansive form will give a good account of itself in competition against any other form of gas which can only be used in an explosive form.

An important feature in the use of steam gas is that it does away with the necessity of storing up heat in large volumes of explodable water, the safer method of storing up heat is an equal weight of steel tubing being practicable, the volume of water contained in the latter being so small that the present danger from explosion would cease to exist.

With the general introduction of steam gas it will be interesting to watch the change which the turbine type of engine will have to undergo to enable it to compete with the reciprocating engine, the latter of which, at the present moment, being able to make use of steam heated up to a temperature of 1000 deg. JOHN RIEKIE.

Argaith, Dumbreck, November 26th.

A CENTRIFUGAL PROBLEM.

SIR,—An engineer is often more at home in dealing with concrete cases, however complicated, than with abstract conceptions, however simple. No other explanation can I see for the diverse opinions which a simple problem has called forth from a small circle of engineers of my acquaintance.

We were whiling away an idle evening at one of the music halls, when the usual state of boredom was relieved by the appearance on the stage of a vast hollow sphere in which was a motor cyclist, the sides of the sphere being sufficiently perforated to allow of a clear view by the audience. The cyclist commenced to ride round and round inside the sphere until, having developed sufficient velocity, he was enabled to encircle the sphere in its vertical great circle, centrifugal force enabling him to keep this up as long as desired.

This simple feat accomplished, we were about to relapse into the state of boredom—perhaps pardonable in such an environment—when I suggested that this popular exhibition of centrifugal phenomena might be rendered much more striking by causing the sphere to rotate about a horizontal axis with a peripheral velocity equal and opposite to the linear velocity of the cyclist, so that the cyclist would become stationary relative to objects outside the sphere. By slightly increasing his speed he could then creep slowly round the interior, and, on arriving at the top, he could, if he wished, remain stationary—*i.e.*, relative to the audience. I was surprised to find opinions divided on this point, some arguing that by the compounding of the two velocities the cyclist would lose his centrifugal force and must fall, while others agreed with me that the loss of centrifugal force was only apparent, and that the feat was feasible.

It is easy to propound a problem, and it may be easy to solve it, but, as I have found to my cost, it is quite another matter to convince one's friends, and it is in the hope that an authoritative expression of opinion will effect what my unaided arguments have failed to achieve, that I humbly request the publicity of your columns.

November 21st. A. B. C.

THE GRANTHAM DISASTER.

SIR,—Will Mr. Stretton kindly say on what company's line he made his ride in a brake van, and also the name or situation of the place where the speed restriction to 40 miles an hour is in force? Further, it is of importance to know the actual reduction in vacuum effected by the driver at each of the three successive applications of the brake on the occasion to which Mr. Stretton alludes.

If the brake is properly handled, there ought to be no jerkiness, and the rule is that not less than 5in. of vacuum should be destroyed in making an initial application. I see no grounds for the brake failing in the manner it is alleged to have failed, unless it was operated inefficiently. In order to bring the speed down from 79¼ miles an hour to 40, I can scarcely believe that a competent man would at first use less than 5in. of vacuum, and such a reduction would not cause any unpleasantness to the passengers.

I agree that the fact of the large "Atlantic" engine having moved on its side for a distance of 60ft. does not enable us to arrive at the speed of the train with exactitude, but it at least shows that a considerable amount of energy must have been absorbed by the overturned locomotive before it came to rest.

Mr. Stretton thinks that a bogie tender might have safely rounded the curve of the Nottingham branch crossover road. Assuming the brake to be hard on, is it not probable that the effect of the blocks tightly gripping the wheels would be largely to neutralise the free movement of the bogies about the centre pins? It may also be worth while to point out that the bogie tender at Salisbury was derailed, though it is possible that the circumstances in the two cases are not alike. In any event, the question as to the tender is virtually disposed of by the fact that the Scotch train had no business to be on the Nottingham branch at all, and certainly no train whatever would usually be running on it at high speed at Grantham. As the signalman at the North Box is stated to have acted in accordance with the company's rules, I hardly think that it was a case of "neglect" on his part in keeping the points open.

Mr. Stretton places the Salisbury disaster under the same category as the Grantham and St. Pancras accidents, in so far as the vacuum brake is concerned. I do not think, however, that the vacuum brake had anything more to do with the Salisbury catastrophe than the Westinghouse brake had to do with the Witham derailment. F. W. BREWER.

Bowes Park, N., November 24th.

[Our correspondents will learn with regret that Mr. Clement Stretton, who has taken such an active interest in this discussion, is seriously ill, and they will join with us in hoping that his recovery may be rapid and complete.—ED. THE E.]

THE CHANNEL TUNNEL.

SIR,—The impression which the public naturally obtains from the revived proposal of the Channel Tunnel scheme is of a possible through-carriage journey from London to Paris and other continental cities.

In view of the difference of 1½in. in the gauges of the English and Continental railways, one change of carriage and transhipment of goods will be necessary at some point near the tunnel, unless, of course, a new double-track railway from London to Dover is included in the scheme.

This appears highly desirable, as the evils of a break of gauge have been experienced in Egypt, where reconstruction to secure uniformity has been found necessary. J. B. W.

November 26th.

[This mistake has been made on several other occasions, and we publish "J. B. W.'s" letter as it gives us an opportunity of correcting it. The gauge of the Northern Railway of France is 1·44 m., which is quite near enough to 4ft. 8½in. for trains to run right through. There are differences in the French gauges, but locomotives suited to 4ft. 8½in. gauge can run over nearly all French lines.—ED. THE E.]

FERRO-CONCRETE.

SIR,—Will you permit me to supplement the interesting record in your issue of November 16th of what has been done by various committees investigating armoured concrete, by reminding you that at the recent Brussels Congress of the International Association for Testing Materials it was unanimously resolved to appoint a committee to consider the matter from an international point of view. Messrs. Martens (Berlin), Schüle (Zurich), and Mesnager (Paris), were requested to draw up the terms of reference for the committee which will be appointed by the Council of the Association at their meeting in February next. On this committee the two British representatives proposed are Mr. Edwin O Sachs, chairman of the British Fire Prevention Committee, and Mr. Max Clarke, member of the Reinforced Concrete Committee of the Royal Institute of British Architects.

Westminster, November 19th. BENNETT H. BROUGH.

STEAM AS A MOTIVE POWER FOR PUBLIC SERVICE VEHICLES.*

By Mr. Thomas Clarkson, Member, of Chelmsford.

(*Concluded from page 535.*)

General arrangement: Plan and elevation, Fig. 9, page 553, and front view, Fig. 10.—An air condenser is placed in the front of the chassis, thus having the advantage of fresh air, which is circulated through the condenser by a propeller fan. The condenser forms the front of the bonnet, and in this is housed the automatic steam generator. The rear of the bonnet is closed by a plate, between which and the body of the omnibus a 1in. air space is provided. The engine is between the generator and the rear driving axle. The cylinders lie horizontally, and forward of the engine. The engine gear is completely enclosed, and the motion is transmitted from the crank shaft to the differential by spur gear in the reduced ratio of 3 to 1.

The differential gear—Fig. 11—is of the spur type, which is preferred to the bevel type on the score of simplicity and the elimination of end thrust. The two halves of the differential shaft carry the excentrics for actuating the pumps, and to the outer ends of the differential shafts are fitted brake drums, and also the chain sprockets through which the power is transmitted direct to the road wheels. Particular attention is drawn to the fact that no change gears or disengaging clutches are employed. An average gear ratio is selected between the engine and the driving wheels of such proportion that the omnibus can easily ascend or start up the steepest hills when fully loaded, and it also enables a speed to be obtained on the level sufficiently high for practical purposes upon a public service vehicle. This important result is obtained simply from the remarkable flexibility of the steam, and herein rests one of the greatest advantages of the system.

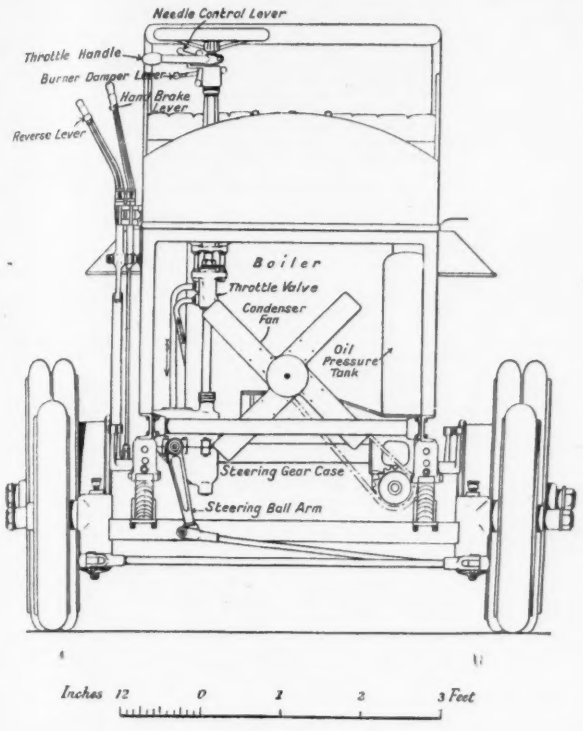


Fig. 10—*Chelmsford Steam Omnibus.*

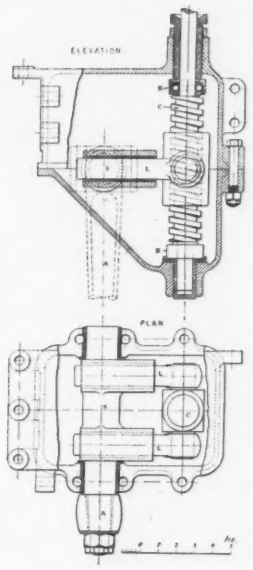


Fig. 12—*Steering Gear.*

which carry the brake blocks, swing upon a couple of studs, which are bolted to the main frame. The outer ends of the studs are held together by a tie-plate T, and so prevented from separating. The lower ends of the levers are forced together by the lever J, whose upper end is moved by the foot lever. The lower end of lever J is connected to the brake block levers in such a way that each lever acts as a fulcrum to the other. In this way a fairly even pressure upon both brake blocks is secured. Adjustable stops are provided at the top to ensure a proper amount of clearance for each block, and to prevent rubbing when out of use. The equalising of the brake load upon both sides of the car is effected by a balance lever pivoted to the foot gear. The brake drums are renewable without interfering with the arms or the centre boss.

The second brake—Fig. 14—is actuated by a side lever, which causes two segmental blocks to be expanded within a drum—that is, bolted to each of the driving wheels; upon the outer part the chain-driving sprocket is formed, and the brake load is balanced on the two wheels in a similar manner to the foot brake. No flexible connections are used.

The third brake is available in the engine, since by merely reversing the valve gear a considerable resistance is offered to the movement of the car, even if steam is shut off. A still greater brake power is available if steam is admitted to the engine when in reverse gear, and the engine is constructed very substantially, so as to take this somewhat rough treatment without suffering inconvenience.

Tires and skidding.—The employment of rubber or other soft material seems to be essential. Experiments are being made with tires of leather, indurated felt, wood, and linoleum, but, so far, rubber holds the field. The cost of rubber is 2d. a mile on a 34-passenger omnibus. The principal cause of wear in tires is the excessive use of the brakes and the violent starts, which are uncomfortable to the passengers, as well as destructive to the tires. A careful driver of a steamer can control his car almost entirely by the throttle, and uses the brakes but seldom, except in crowded traffic. The sudden application of the brakes or the violent opening of the throttle naturally tends to cause circumferential slipping. When this commences the tire loses its grip on the road surface, and it may then slip in any other direction, hence the development of "side-slip."

Lubrication.—The general lubrication of the engine and differential gear is by a system of pump circulation combined with an automatic distributing valve—Fig. 15—which supplies the oil to each of the bearings successively. The engine and differential cases are combined, and a well or sump is fitted at the lowest point. Into this all the surplus oil drains from every bearing, and from the sump the oil is delivered by a force-pump into a circular valve-box which is connected by a pipe with every bearing of the mechanism. To provide against the possibility of any of these distributing pipes becoming fouled or obstructed, a circular valve is provided which covers up all the outlets of the distributing pipes with the exception of one. This one has, therefore, to take the whole of the oil which is delivered by the pump. The distributing valve is slowly rotated by a worm gear on the differential shaft, and so the delivery of oil is automatically transferred from one bearing to another, and the possibility of a stoppage is avoided. It naturally happens that some of the distributing pipes are much longer than others—depending upon the distance of the distributor from each of the bearings. This, however, does not reduce the quantity of the oil supplied, even to the most distant bearing, but when the longest pipe is switched on to the pump the latter absorbs a little more power in forcing the same quantity of oil through the longer pipe. The system has the important advantage of taking out of the hands of the driver the responsibility for attention to lubrication, particularly for the high-speed mechanism. Also the lubrication commences and ceases simultaneously with the running of the mechanism. The consumption of oil is relatively small, as the same oil is continually being used, and any dirt or mechanical impurities is allowed to precipitate on the bottom of the sump. This secures a more effective distribution than obtained by splash lubrication, and the oil is not lashed up into foam.

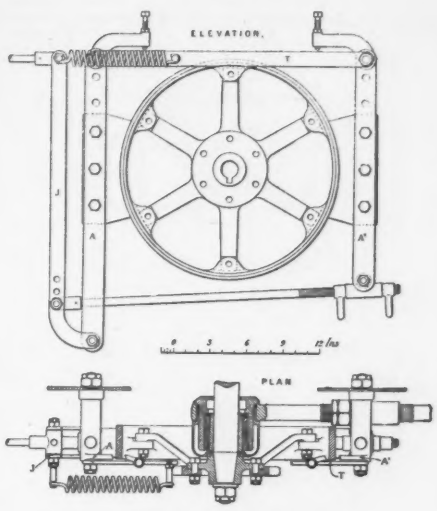


Fig. 13—*Differential Brake Gear.*

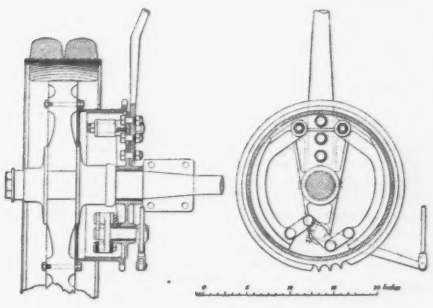


Fig. 14—*Section of Driving Wheel and Brake Drum.*

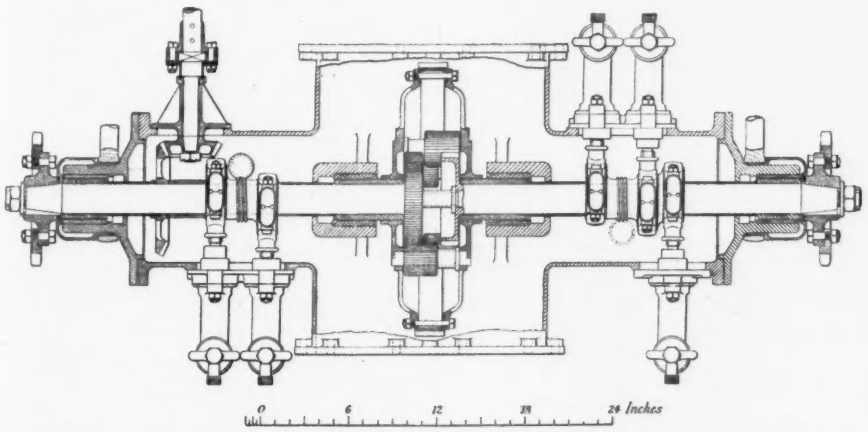


Fig. 11. *Differential Gear and Case, showing Pump and Chain Sprockets.*

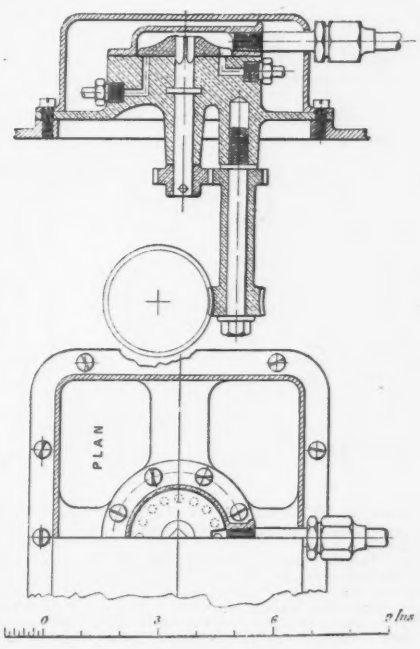


Fig. 15. *Assembly of Oil Distributor.*

Steering gear.—The control of direction is effected through the gear shown in Fig. 12. The hand-wheel shaft is coupled directly to the square-threaded screw, which causes the long bronze nut to rise or fall as the wheel is moved. On each side of the nut projects a trunnion, which carries the ends of the two sliding plunger levers L L. It will be clear how an oscillating movement is imparted by this gear to the nickel steel rock shafts. Upon the outer end of this shaft is securely fixed the swinging arm A, which is coupled at its lower extremity to the Ackermann axle. The gear is enclosed in a dust-tight case of aluminium, and the end thrust of the screw C is taken by ball bearings B.

Brakes.—Three independent brakes are provided. The first brake—Fig. 13—is operated by a foot lever, and causes blocks to be applied to both sides of an 18in. drum which is fixed to each of the outer ends of the differential shaft. The two levers A A^1,

Cylinder lubrication.—Owing to the temperature of the steam a high grade of hydrocarbon oil must be used for the interior lubrication of the engine—that is, for cylinders and valves. It is

* The Institution of Mechanical Engineers.

also necessary that this oil should be fed with great certainty and regularity, so as to maintain a film of oil over the working surfaces in the most economical manner. The result of the author's experience has led him to adopt a system of force-pump feed, and the general arrangement of the cylinder lubrication is shown on Fig. 16. In this drawing it will be noted that an aluminium box, which forms the reservoir for cylinder oil, also contains two pumps, the plungers of which are forced down sharply at regular intervals by a cam-operated spring. There is no packing of any kind in the pumps, but the plungers are made a good fit. After the cylinder lubricator has been charged, no further attention to cylinder lubrication is necessary for 1000 miles. This also has a great advantage in securing regularity of working, and is again quite

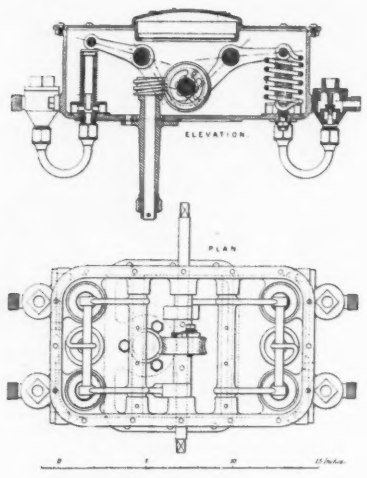


FIG. 16—*Cylinder Lubricator*

outside the sphere of the driver. It merely requires periodical inspection and replenishment from the engineer in charge of the garage. The oil is introduced into the steam pipe close to the engine, and is carried through with the exhaust into the condenser, from which it returns back into the water tank. Previously a filter was provided to separate this oil from the water of condensation, which is used again for boiler feed. This, however, has been found unnecessary, and the oil is allowed to collect upon the surface of the water, from which it may be skimmed at the end of each day. This skimmed oil is saved, and is found to answer extremely well for lubrication of other parts, such as chains, hubs, steering gear, &c This oil may also be used again for cylinder lubrication after filtration. The cost of lubricants is, therefore, very small indeed.

General arrangement of engine—Fig. 17.—The engine has two horizontal double-acting cylinders, 4in. diameter by 4in. stroke, which are in two separate castings, with a view to prevent distortion by the employment of highly superheated steam. The cylinders are attached to distance-pieces, bolted to the outside of the aluminium gear-box, which contains the crank shaft, cross-heads, connecting-rod, and all the valve motion. It is found convenient to place the valves for the distribution of the steam beneath the cylinders, as this dispenses with the necessity for the employment of drain-cocks for removing the water of condensation at starting. The water readily gets away through the exhaust immediately the port is opened, and the employment of drain-cocks has been found unsatisfactory in the hands of the ordinary driver, for they will either omit to open them or leave them open, which might not be readily observed, as they must necessarily blow into the condenser, or they give trouble through leakage. The elimination of the drain-cock is therefore an important advantage.

The valves are of the piston type, fitted with rings, and are actuated by Joy gear. This enables a very simple form of crank shaft to be employed, which is built up of two parts, each forged out of the solid, and bolted together, with a steel spur wheel in the centre. The cranks are at right angles, and the crank shaft is hardened and ground on both the journal and the crank pins. No adjustment is provided in the engine motion, but the principle is adopted of giving very large and well-fitted surfaces of the hardest bronze, working against a hardened and ground steel face, and with a constant flow of oil over them. In this way the wear is reduced to a minimum, the time of making adjustments is saved, and the risk of bungling over adjustments and the consequent excessive friction and wear are obviated. Such an engine will run 30,000 miles without getting any appreciable knock, and when the knock develops, it is arranged to readily fit new bronze bushes into the motion.

This engine has been in regular public service on single-deck

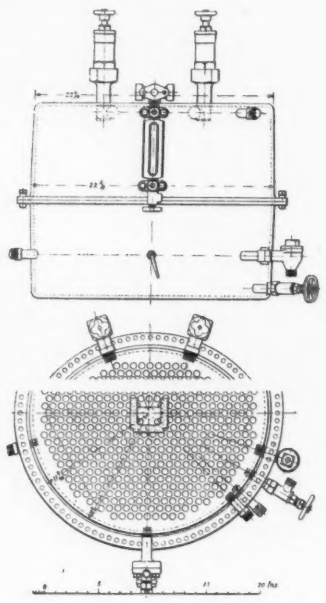


FIG. 18—*Fire-tube Boiler, Single-deck Omnibus*

omnibuses for three years in Devonshire. The maintenance costs are shown below:—

	1st year to Oct, 1904. Ponce per mile.	2nd year to Oct., 1905. Pence per mile.
Wages	3·63	3·08
Fuel	1·43	1·15
Lubricating oil	0·205	0·11
Repairs, &c.	1·81	1·17
All other expenses, insurance, uniforms, establishment expenses	1·32	0·72
Total operating expenses	8·4	6·23
Tires	1·5	1·5
Depreciation	1·29	1·16
	11·19	8·89

A similar omnibus upon another service in Gloucestershire is reported by the owner as follows:—"The mileage done by the car in question is as near as possible 27,000 miles—7th October. The only replacements to the engine are piston-rod bushes, crosshead guide bushes, piston-rod sleeves, and piston rings. The total cost of materials comes to £1 13s. Original valve-spindle bushes are in use; original cast iron slide valves are in use, and in good condition; all original pump-plungers are in use, and show hardly any wear; paraffin plunger slightly scored but pressure is well maintained. The valves in pumps have never been ground, or their seats touched. The lubrication of engine and cylinders has been most satisfactory, and the automatic lubricators have given practically no trouble, with the single exception of one failure of a cylinder lubricator check valve, owing to a soft ball allowing steam to pass, it being battered out of shape. This occurred during first week of running. As to the car generally, the original chain wheels are in use, the original brake drums are in use, and one original front tire is in use. The fuel consumption averages one gallon to 4⅓ miles."

On these omnibuses a simple form of fire-tube generator is used, which is illustrated on Fig. 18.

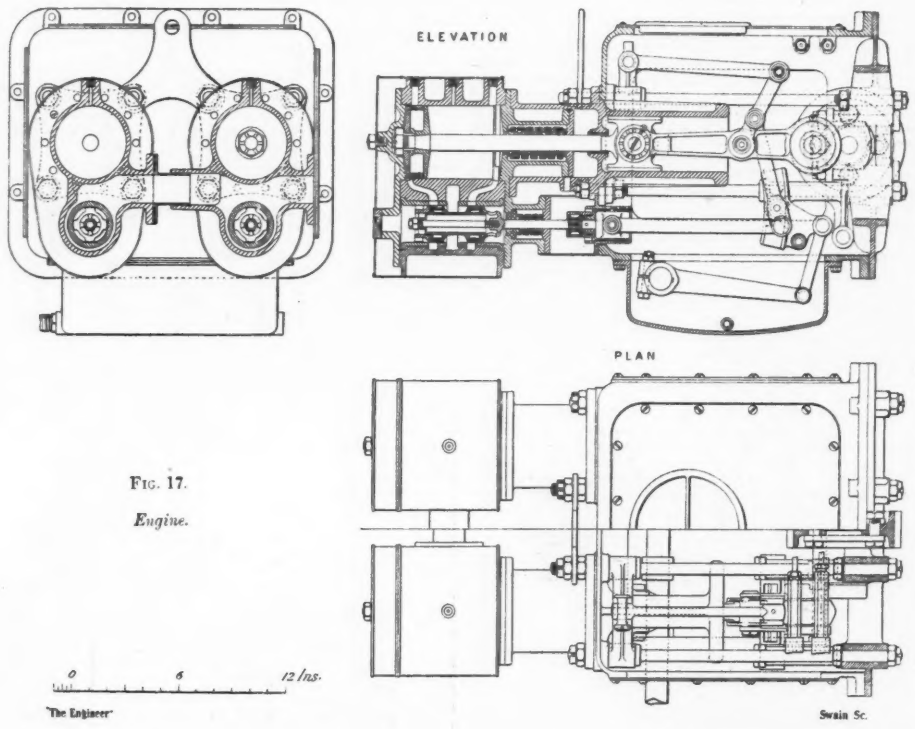


FIG. 17.

Engine.

ROYAL AGRICULTURAL SOCIETY.

THE Royal Agricultural Society make the following announcement regarding the Lincoln Show, which is to take place from June 25th to 29th, 1907:—

Trials of swath turners and side delivery rakes have been arranged, and the following awards will be made:—Class I.—Swath turners: First prize, silver medal; second prize, bronze medal. Class II.—Side delivery rakes: First prize, silver medal; second prize, bronze medal.

The entries for these prizes must be sent to the secretary, 16, Bedford-square, London, W.C., on or before Friday, March 15th, 1907, and must be accompanied by a deposit of £5 for each entry. Such deposit will be forfeited if the machine is not submitted for competition at the time appointed for the trials and is not exhibited at the Lincoln Show.

The trials will be subject to the following regulations:—

(1) The trials will be held in the neighbourhood of Lincoln on or about the third week in June. The locality and the exact date will be notified as soon as it can be ascertained when the crops will be ready.

(2) Entries for these prizes must be made on the Society's forms, together with detailed specifications giving general over-all dimensions and setting out the special merits claimed for the machines.

(3) Provision will be made by the Society for the housing of the several implements competing, but the competitors must arrange for the delivery of their machines to the site, and also provide the necessary horses for the trials.

(4) Each competitor, or his representative, to be present to give any desired information to the judges, and to direct generally the working of the machine, but only one man must actually work the machine.

(5) The trials will be made as far as practicable under similar conditions as would rule in the use of the machines in ordinary work on a farm.

(6) The trials will be conducted on ridge and furrow land, as well as on the flat.

(7) Trials will also be made with the dynamometer to ascertain the draught and load on the horse's back, and each machine must be weighed either before or after the trial.

(8) The points to which the judges' attention will be specially directed are:—

(*a*) Mechanical construction.
(*b*) Weight and draught.
(*c*) Ease of handling and adjustment.
(*d*) Efficient turning over of the crop.
(*e*) Freedom from winding or choking.
(*f*) Adaptability of windrowing as well as swath turning.
(*g*) Adaptability for working on ridge and furrow land.
(*h*) Adaptability for transport on road and rail.
(*j*) Price.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—A meeting will be held at the Caxton Hall, Westminster, S.W., on Thursday, December 6th, 1906, at 8 p.m., when a paper will be read on "Boilers and their Accessories," by Mr. R. J. P. Briggs, S.I.C.E.

THE INSTITUTION OF MECHANICAL ENGINEERS.—An extra meeting will be held this evening at 8 p.m., when the discussion will be continued on "Steam as a Motive Power for Public Service Vehicles," by Mr. Thomas Clarkson, Member, of Chelmsford.

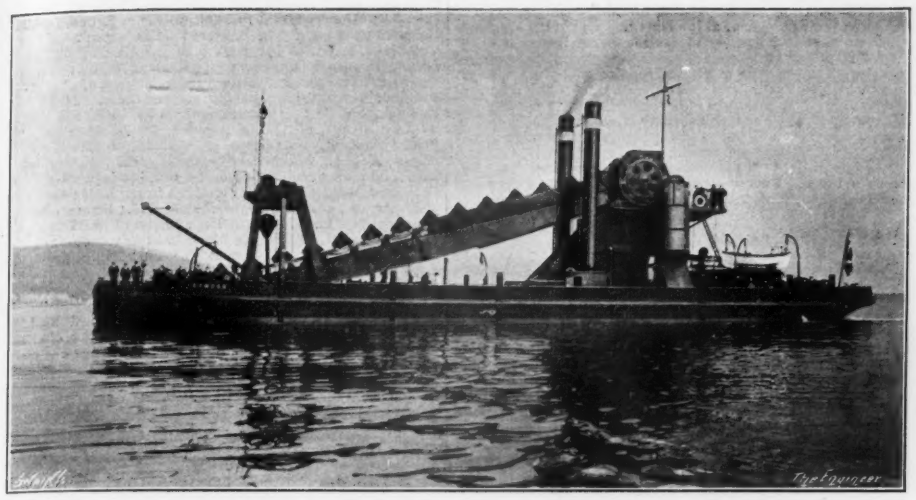
SOCIETY OF ARTS.—Viscount Milner will preside at the opening meeting of the Colonial Section of the Society of Arts on Tuesday afternoon, December 4th, when the Hon. Sir Lewis Michell, late Member of the Cape Ministry, will read a paper, illustrated, on "The Cape to Cairo Railway." The chair will be taken at 4.30.

INSTITUTION OF CIVIL ENGINEERS: GLASGOW ASSOCIATION OF STUDENTS.—The opening meeting of the present session of this body was held in the Institution Rooms, Bath-street, Glasgow, on 19th inst., Mr. Donald A. Matheson, M. Inst. C.E., engineer-in-chief of the Caledonian Railway, presiding. Having thanked the members for electing him president for a second term, he devoted his presidential address to "The Economics of Civil Engineering Work from the Point of View of the Cost of Maintenance." The question of the economics of civil engineering, he said, did not always receive the consideration from civil engineers and others which its importance demanded. The young civil engineer, in particular, was prone to overlook the terribly insidious and stealthy action of some of the forces of Nature, and to forget that things wore out. The financial consequences were serious and far-reaching, and it was essential that work should be skilfully designed and durably constructed. There was the necessity for economy in first cost from the point of view of the minimum charge of interest on capital expended, and there was the necessity for sound judgment of quality and sufficiency from the point of view of the cost of maintenance. Oversufficiency and insufficiency were equally bad engineering. Civil engineering was the art of making a sovereign earn the most interest, and the commercial element was everywhere present in all civil engineering work. He pleaded for durability, for in civil engineering, as in everything else, "the whirligig of time brings in its revenges." He advised them so to educate themselves and train their minds as to get instinctively to feel throughout the entire course of their professional career that they were being continually stalked by the spectre of expenditure in maintenance. Thereafter the successful essay in the competition for the president's prize, entitled "A Brief History of Civil Engineering," was read by the author, Mr. J. B. Harvey, Stud. Inst. C.E.

GAS STOVE TESTS.—A report has been issued by the Coal Smoke Abatement Society, dealing with tests made in May and June last with gas stoves. Twenty-five stoves, representing nine manufacturers' patterns, were selected. Summing up the tests, the report states that a properly constructed gas stove, with a flue sufficiently large to carry away the products of combustion, although for constant work more costly than a coal fire, is quite as satisfactory from a hygienic point of view, and does not in any way vitiate the air of the room, nor does it produce any abnormal drying effect, as is popularly supposed. It will carry off from about 2000 to 4000 cubic feet of air per hour, and this is a valuable ventilating effect. It is only in the very largest gas fires that the calorific value of the fuel burnt per hour approaches that obtained in coal fires, being in the majority of cases only about one-third. The percentage which is lost in the flue gases is, however, greater in the best coal than in the best gas fires. When the initial raising of the temperature of the rooms had been accomplished and the fires had produced a fairly steady rise, the cost per hour for each degree of rise in temperature was about four times as great with the gas fires as with the coal. This does not necessarily mean that gas is always more costly than coal; other factors must be considered, such as the rate at which the room is warmed. It was found that while the gas fires usually produced a fairly steady temperature in the rooms in from one to two hours, the coal fires took much longer. Taking into consideration the amount of coal which must be burnt before a comfortable and steady warmth is produced, and also the amount which must be burnt after the fire is no longer required, the examiners think that even from the point of view of economy the gas would run the coal very closely for domestic uses, where it is seldom necessary to have a fire constantly burning for long periods. It is the lighting and letting out which make the coal fire wasteful. The flueless condensing gas fires, while very economical of gas, pour into the room a large quantity of carbon dioxide gas. With plenty of ventilation they would be very suitable for warming rooms or passages where no flue existed to which an ordinary gas fire might be connected. These stoves make the most economical use of the gas burnt, but this is due chiefly to the absence of a flue and the consequent losses through it.

BUCKET DREDGER FLEETWOOD

FERGUSON BROTHERS, PORT GLASGOW, ENGINEERS



THE BUCKET DREDGER FLEETWOOD.

THE bucket dredger Fleetwood, launched on the 20th September by Messrs. Ferguson Brothers, Port Glasgow, for the Lancashire and Yorkshire and London and North-Western Joint Railway Companies, was recently tried on the measured mile and attained, we are informed, a mean speed of fully half a knot in excess of specification. She afterwards proceeded to Fleetwood, where dredging trials were carried out under the direction of Mr. L. Franklin, Mr. A. T. Gibson, and Captain Bond. The results were considered satisfactory, dredging being done with hopper barges at the rate of 1150 tons per hour.

The vessel, which, as is quite customary with this type of craft, was launched complete with machinery aboard and steam up, is the largest and most powerful bucket dredger owned by the company. She is of the bow-well centre bucket ladder type, length 172ft. by 36ft. 6in. by 12ft. moulded, and is designed to raise 900 tons per hour. She is built to Lloyd's highest class. The bucket ladder and box framings for supporting the chain of buckets and dredging gear has been constructed of girder work, all put together and connected with steel rivets closed by hydraulic pressure. Side shoots are arranged for discharging the dredged material over either side of vessel into hopper barges, the lifting and lowering of each shoot being worked by an independent engine. The regulation of the discharge of the spoil to either side of vessel is controlled by a strong flap valve door fixed at the apex of the shoots and worked by gear from the main deck. Separate accommodation is provided under deck for the captain, engineers, crew, and ladder men, special pro- vision being made for light and ventilation. Steering gear is fitted on the bridge, which is placed at the top of the main gear framing.

A complete installation of electric light is fitted throughout. Heavy elm beltings are fitted all round the vessel, and also strong vertical fenders at intervals to take the wear of the barges lying alongside. The bucket ladder is suspended independently of the upper tumbler shaft. The main engines, which are employed for either propelling the vessel or driving the dredging gear, consist of one set of the triple-expansion surface-condensing inverted direct-acting type, having three cranks, and designed to indicate 700 horse-power. Steam reversing gear is fitted. Steam is supplied from two cylindrical return multitubular boilers constructed under Lloyd's special survey. The dredging machinery is of massive design. The gearing is arranged to work the buckets at two different speeds, according to the nature of material being dredged. All wheels, pinions, clutches, tumblers, and bucket backs are of cast steel. The upper tumbler shaft is driven by a friction spur-wheel of large diameter and capable of being adjusted to convey the necessary power to the buckets according to the hardness of material being worked. The hoisting gear for the bucket ladder consists of a heavy wire-rope tackle working in upper and lower sheave blocks suspended from a crosshead fixed on a box-framing structure built into the vessel at the forward end of the vessel, the lower sheave blocks being connected to the bucket ladder by forged side rods; the wire rope is wound on a large grooved barrel driven by gearing from a double-cylinder engine, all this machinery being placed under deck. The wheels and handles for working this gear are, however, placed on deck so as to be under the control of the dredging master. The dredger buckets each have a capacity of 21 cubic feet. A crane is fitted on deck for overhauling the buckets and links and for general purposes.

Six steam winches are fitted on board—three at the bow and three at the stern of vessel—these being for manipulating the mooring chains and for holding the dredger up to its work. Each winch is driven by a two-cylinder engine. The dredger was to be capable of propelling herself at a rate of speed of seven knots per hour, and, as we have already said, she actually went half a knot faster than this.

RAILWAY CLUB.—The last meeting was held on Tuesday, November 13th, at 92, Victoria-street, London, S.W., Mr. Geoffrey Haly in the chair, when Mr. H. W. Bardsley read a paper entitled "Some Curiosities in Railway Time-tables and Notices."

SHEFFIELD STUDENTS' ENGINEERING AND METALLURGICAL SOCIETY.—At the University Department of Applied Science, on the 20th inst., Mr. Z. T. R. Wood read a paper on the "Bessemer Process" before the members of the Students' Engineering and Metallurgical Society. The lecturer gave a historical sketch of the process, describing the modern converter, the arrangement of the shop and its various appliances, the mode of the process, and the chemistry of the acid and basic processes. The lecture was illustrated by lantern slides, and was followed by a discussion. Mr. F. K. Knowles presided.

A MULTIPLE DRILL HEAD.

A DEVICE called the "Bamag" drill head has recently been brought to our notice by the maker, Mr. O. N. Beck, of 11, Queen Victoria-street, E.C. The drill head, which

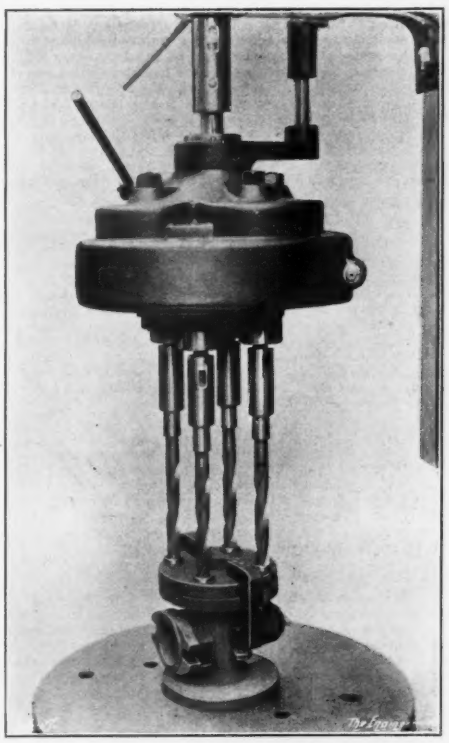


Fig. 1—MULTIPLE DRILL HEAD

we illustrate in Fig. 1, is used for simultaneously drilling four holes up to 2in. in diameter, at pitches varying from 2½in. to 7½in. This, however, is not its only

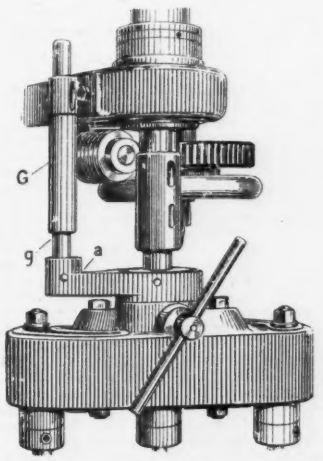


Fig. 2—ATTACHMENT TO MACHINE

function. It can be used for boring out cored holes, machining facings, and tapping holes up to 1¼in. gas thread. A sectional view of a three-spindle head is given in Fig. 3. This type of drill head can only be employed on machines in which the spindle sleeve *m* participates in the feed of the spindle. When axial feed is given to the spindle only, then the arrangement shown in Fig. 2 is adopted. A general idea of the construction of the device is shown in Fig. 3, which is a section of a three-spindle drill head. The bush *b* is firmly fixed to the sleeve spindle by means of a bolt tightened against the rack. The part *a* is secured to *b* in such a manner tha it can be held tight, thus forming part of it, or it can be left free to turn in order to allow adjustments to be made. The

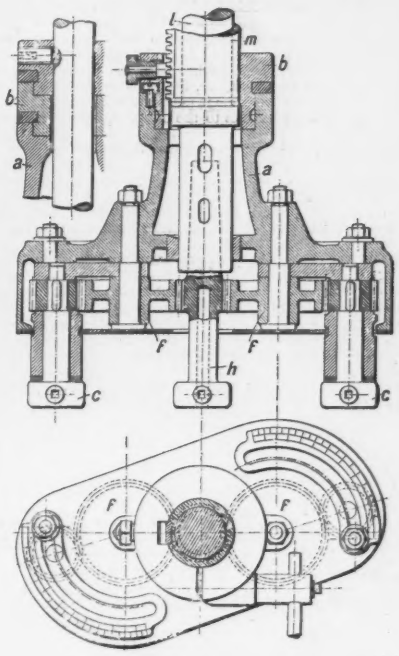


Fig. 3—SECTION AND PLAN

rotation of the central spindle is transmitted through the pinions *ff* to the outer drill holders *cc*.

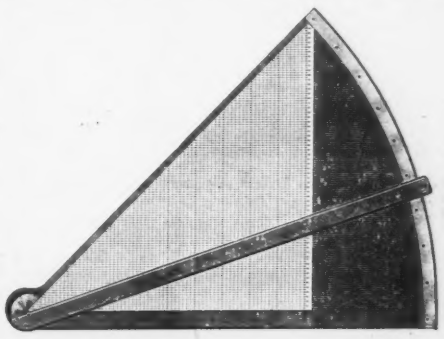
In machines where the vertical feed only is given to the spindle a slightly modified arrangement – shown in Fig. 2—is adopted. The head is applied direct to the spindle, as in the first case, and is held in position by means of a key. In this instance the bush *b* has an arm *a* attached to it, whereby the steel bar *q* is carried, which slides up and down in the guide G. This keeps the drill head in one position. This guide can be fitted to any convenient part of the drilling machine. The drills can be "set" quickly to suit any pitch within the range of the drill head, and we are informed that the device can be fitted to any type of drilling machine.

AN INCH-DWT. CALCULATOR.

WE have had sent to us for inspection a new calculating machine, the invention of a Mr. William Crossley. The instrument is manufactured and supplied by W. F. Stanley and Co., Limited, of Great Turnstile, W.C. Most of our readers are no doubt aware that it is necessary, in connection with mining operations, to make numerous calculations which involve the multiplication of two numbers, the product being divided by a third number. This calculation is known as the inch-dwt., and it enables each pair of values in a list of assays to be at once written down at the value on any selected common basis of a fixed stoping width. The calculation involved is:—

$$\frac{m \text{ inches} \times n \text{ dwts.}}{y \text{ inches of stoping width.}}$$

The calculator, of which we give an illustration, consists of a sector of a circle on which is drawn a right-angled triangle. The base of this triangle is divided into 60 equal



parts, and the side of the triangle is also marked off into parts which are equal to the divisions of the base. In the actual apparatus the base is equal to the side, so that there are 60 parts in each. Lines are drawn vertically and horizontally through the points where the divisions are made. The lines drawn vertically from the base are inch lines, and the space between each one is decimally divided by lines drawn parallel to them. The lines at the points representing 30, 36, 42, 48, 54, and 60 inches are drawn bolder than the others, because they are the most likely to be selected for stoping widths. The divisions on the ordinate represent dwts. These divisions are also decimally divided. There is, therefore, a number of squares formed by the two sets of parallel lines.

To determine the required result $\frac{x \text{ dwt.} \times y \text{ inches}}{n \text{ inches}}$ the edge of the radial arm is brought to the point where the x dwts. cross the y inch line, and it is then held in that position by the thumb-screw. The required answer will be

found where the line on the edge of the arm crosses the *n* inch line. If any value in dwts. numerically higher than the chosen stoping width is desired, units must be read as tens, and tens as hundreds. Besides the ordinary flat form of calculator which we illustrate, the instrument is also made in the shape of a cone, being supported at the apex, and at a point at the centre of the base, the radial arm in this instance being fixed on brackets.

AUSTRALIAN NOTES.

A RECORD result has been achieved on the Victorian railways in the working for the past year. It is undoubtedly the fact that since the present management has been in operation, with Mr. T. Tait as Chief Commissioner, the railways have been entirely reorganised. At the same time it must not be forgotten that much of the financial success is due to the unique system of rearranging the accounts.

Where railways in other countries are compelled to follow out a uniform system of presenting their accounts, in Australia each State railway can adopt a principle of its own. Referring to Victoria, certain items of extraordinary expenditure are charged against surplus revenue, and do not appear against working expenses at all; in other States the same items are made a direct charge against working expenses.

For the year ended June last the railways show a surplus, after meeting all charges, including interest of £198,965. which it is recommended should be used to liquidate the extraordinary liabilities which the railways have to bear.

The only new lines opened during the year was an electric street railway from St. Kilda railway station to Park-street, Middle Brighton, about four miles in length, which was opened for traffic on May 7th.

A summary showing the results of the traffic for the year, and a comparison of the previous, is given as follows:

Victorian Railways.

	Year ended June, 1905.	Year ended June, 1906.
Capital expended on lines open	£41,279,045	£41,398,037
Average cost per mile	£12,162	£12,194
Total miles open for traffic	3,394	3,394
Average miles open	3,384	3,394
Gross revenue	£3,582,266	£3,787,619*
Working expenses (exc. of extraordinary liabilities)	£1,871,138	£1,999,023*
Net revenue	£1,711,128	£1,788,596*
Special expenditure out of the year's railway revenue	£248,485	£117,542
Net interest charges for the year	£1,461,904	£1,472,797
Surplus	£649	£198,965
No. passenger journeys	59,702,050	65,068,394
Tonnage of goods and live-stock	3,628,237	3,676,017
Train mileage	9,023,365	9,392,069

* Exclusive of St. Kilda electric line.

PHYSICAL SOCIETY OF LONDON.—The second annual exhibition of electrical, optical, and other physical apparatus will be held on Friday, December 14th, 1906, from 7 p.m. to 10 p.m. in the Physics Laboratory, Royal College of Science, Imperial Institute-road, South Kensington. Council meeting at 8 p.m.

COLD STORAGE AND ICE ASSOCIATION.—The next meeting of the Cold Storage and Ice Association will be held at the London Chamber of Commerce, Oxford-court, Cannon-street, E.C., on Tuesday, December 4th, at 7.30 p.m., when Mr. Worby Beaumont, M. Inst. C.E., M.I. Mech. E., will introduce a discussion on "Motor Traction in the Cold Storage and Ice Industries."

JUNIOR INSTITUTION OF ENGINEERS.—Monday, 3rd December, 8 p.m., at the Westminster Palace Hotel: Combined meeting with the Discussion Section of Architectural Association. Paper on "The Structural Design of Engineering Factories," by Mr. Adam Hunter, Assoc. M. Inst. C.E (past-chairman). Saturday, 8th December, 3 p.m.: Visit the Honor Oak reservoirs of the Metropolitan Water Board.

MOTOR OMNIBUSES AND SIDE-SLIP.—The Automobile Club is organising a Side-slip and Skid-prevention Competition in January next, with the object of discovering, if possible, a device or devices which will effectively prevent side-slip and skidding by motor omnibuses, and which will stand an amount of wear and tear sufficient to justify their use. The devices must comply with the regulations of the Local Government Board and the Commissioner of Police of the Metropolis The competition will be divided into three parts, namely:—Part 1, examination of drawings; part 2, preliminary test; part 3, road endurance test of about 1000 miles under service conditions. The last day of entry is December 31st next.

IRON ORE DISCOVERIES IN DERBYSHIRE.—Details of what is stated to be an important commercial development were—says the *Sheffield Telegraph*—announced at Wirksworth on the 22nd inst. For about twelve months prospecting has been going on in the Sherbourne Valley, within a few miles of the town of Wirksworth and the Midland Railway branch line Duffield to Wirksworth. The prospecting has been in the hands of mining experts, and the first visit of one from a university disclosed the presence in the valley of large deposits of iron ore, and also of coal, and sand shingle. On the first discovery of the iron ore a sample was sent to Middlesbrough for analysis. This analysis gives a result of 26·95 per cent. of metallic iron, and of ·125 per cent. of sulphur, as against Cleveland ore, which is 33·62 and ·81 respectively. But later samples of the ore taken by one of the Professors of geology at a university gave even better results, showing that in the second sample there was as much as 31·27 per cent. of metallic iron. Coal is also believed to exist to a large extent in the same valley, which extends over six miles square.

A CHINESE LATHE.—On the Wei Hei Wei road in Shanghai is a good turning shop, small but thrifty. It boasts of one lathe only, and the Chinese proprietor made it himself in about two days. The apparatus, according to the *Iron Age*, consists of a rough-hewn wood frame about 7ft. long and 4ft. high. Between the sides of the framework, or what might be called the shafts, sits the workman. Beneath him are two bamboo treadles hinged at one end. To these treadles a leather thong is attached, passing from one to the other, and wrapped several times around a wooden spindle, which revolves backward and forward as the workman moves the treadles up and down with his feet. At what might be called the chuck end of the spindle is a cavity about 4in. in diameter, slanting inwards. Into this a wooden circular piece with a hole in the centre is driven. This is the chuck, and the piece to be turned is knocked into the hole in this wooden chuck, and centered by a few strokes of his hammer in as many seconds. The tool rest looks like a mallet, the handle end stuck into a slot, and held parallel with the spindle, this position being maintained by the chest of the workman steadily pressing against the head of the so-called mallet. The tools used for turning are quite as crude as the lathe. There are very few of them, all hand made and unfinished except the cutting edge, which does the work perfectly. The roughing tool is bent inward at the edge like a hook, and that "heathen Chinee" knows how to use the hook. The way he makes the chips fly as the wooden spindle revolves back and forth is marvellous. Never a cut too deep; always the same steady pressure on the wooden tool rest against his naked chest. And those legs of his! Up and down they go on the bamboo treadles like a walking beam. Every working force of the man is brought into play, and he laughs while he labours.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Iron Trade Boom.

THERE is no mistaking the "boom" conditions of the present iron trade movement as it affects this part of the kingdom. It has been years since business at the ironworks hereabouts was of the existing proportions, or since prices—especially of pig iron—were so high as now. The works are running night and day, yet they cannot keep pace with the orders. Difficulty is also still experienced from the shortness of raw materials, both pig iron and unmanufactured steel, and this scarcity is adding a good deal to ironmasters' current troubles. Consumers of rolled iron have to be satisfied with a delayed and partial execution of orders, i.e., with postponed deliveries. The position is not a convenient one. But it has to be borne. And present appearances are all in the direction of a continuation of the shortage.

Pig Iron Prosperity.

Pig iron sellers are still enjoying an exceedingly prosperous state of trade. The output at the furnaces is being absorbed rapidly and there are absolutely no stocks. Prices are going higher and higher, and the only question with buyers is: "Where will they stop?" Large purchases are not possible because makers have very little iron to sell—many of them none at all. Derbyshire, North Staffs. and South Staffs. part-mine pigs have attained as high a present average as 57s. 6d. to 58s. 6d. per ton for forge numbers, and two brands of Northampton forge iron on Birmingham Exchange this week have actually touched 60s. per ton. Such prices Staffordshire and Midland ironmasters have been absolute strangers to for a very long while.

Inflated Raw Iron Prices.

Raw iron prices at date are very inflated, and the Birmingham market wears a feverish and excited appearance. The excitement reported from Middlesbrough, and the increasing American demand, supervening upon the recent great German buying, largely accounts for the feverish state of things locally. Staffs. pig iron this week is quoted: Common, 52s. 6d. to 53s. 6d.; part-mine, 56s. to 58s. 6d.; best all-mine, 85s. to 90s.; and cold blast, 110s. per ton; Northampton forge pigs are a minimum of 55s. to 57s. 6d. upwards; Derbyshire irons, 56s. to 57s. 6d.; and North Staffs., 57s. to 58s. per ton.

Excitement in Rolled Iron.

The excitement existing in pig iron circles is communicating itself to rolled iron. There are further signs of rolled iron prices assuming the aggressive, and buyers are becoming alarmed. It is impossible to get unmarked bars at anything under the £7 to £7 5s. per ton which lately became the new Association price, and second-class bars are £7 10s. to £7 15s., while North Staffordshire iron ditto are very firm and strong at £7 5s. Hoops are £8, and tube strip £7 2s. 6d. to £7 5s. per ton. The advance of 10s. per ton in galvanised sheets officially announced by the makers last week is confirmed this week, so that the absolute minimum price in this branch is now £13 5s. per ton for 24 w.g. material. Black sheets are quoted: Singles, £8 12s. 6d. to £8 17s. 6d.; doubles, £8 15s. to £9; and trebles, £9 7s. 6d. to £9 12s. 6d. per ton.

Steel.

The end of the Clyde strike has had the effect in this market of creating a new demand for rolled steel, and the steel works, which were previously working night and day in their endeavours to keep pace with orders, are now bewildered which contracts to execute first. Prices are necessarily higher, and any quotations are only kept open for a very few days. Current prices may be named as:—Girder plates, £7 10s. to £7 15s.; joists, £7 to £7 2s. 6d.; engineering angles, £6 15s. to £7; and boiler plates, £8 12s. 6d. to £8 15s. Bessemer billets and bars are quoted £5 17s. 6d. to £6 2s. 6d., and Siemens billets and bars, £6 to £6 5s.—all on the Birmingham Exchange.

Concession to Local Ironworks.

It is pleasing to record that the profits in the iron trade are to be shared by one firm with the workpeople. The Shropshire Iron Company, of which Colonel J. Patchett is the head, has granted the millmen a bonus, and the puddlers are also to be recognised. The men are doing all they can to turn out the full output and retain the high quality of the iron. The concession is greatly appreciated by the workpeople.

Rumoured Collieries Amalgamation.

Once more there are rumours of the amalgamation of several collieries in North Staffordshire having been arranged. By the proposed amalgamation, it is stated, a very much larger sphere will be created for the output, also a great saving of railway rates, the cost of administration and utilisation of plant, electric power and rolling stock, thus ensuring the lowest possible cost of output, and consequently reduced rates to the consumer. These large schemes have been heard of before, but they have not hitherto been realised.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, November 28th.

The Month's Retrospect.

THE month which is closing as these lines are written has been a rather exciting one so far as pig iron is concerned. The principal cause of this has no doubt been the continued and active demand for the United States and Germany. This has had the effect of bringing many buyers into the market who had held aloof, and with experience of the past they are now seeking to cover their forward requirements as far as is consistent with their ideas of a prudent course. So far as observation and inquiry go, we think they are justified in so doing. Makers have been quoting almost prohibitive prices to keep off business. That is certainly the position in Lancashire. On the Iron 'Change on Tuesday the attendance was large and the market was animated. In the case of most, if not all, classes of iron, higher prices were registered. As compared with the opening of November, Lancashire shows little change, having been advanced at the close of October 1s. to 1s. 6d. per ton. Lincolnshire and Derbyshire are 2s. to 3s. dearer, Staffordshire 2s., Middlesbrough 2s., Scotch about 2s., while hematite is between 2s. and 3s., according to delivery. It is said here that finality has not been reached in the upward direction yet, while it is certain that quotations are more or less nominal, and inquiries for quantities have to be submitted to the makers for acceptance.

Finished Iron.

There is the appearance after a long interval of a move in finished iron. One or two agents on 'Change said a general advance was imminent. In all probability an early meeting of the members of the local association will be called to discuss the position. Already we hear that one large maker outside has advanced bars 5s. per ton, but this is only rumour, and not of general application. The position is fairly strong, however.

Steel.

Makers report full order books, and in some cases billets are 5s. per ton dearer.

Manufactured Copper and Brass.

Shows little change. If anything, both tubes and sheets are in rather less inquiry.

Quotations.

Pig iron: Lancashire No. 3 foundry, 64s.; Lincolnshire, 62s. 6d. to 63s.; Staffordshire, 62s.; Derbyshire, 63s. to 64s.; Middlesbrough, open brands, 69s. 4d. Scotch: Gartsherrie, 72s. 3d.; Glengarnock, 70s. 3d. to 71s.; Eglinton, 69s. 3d.; Dalmellington, 69s. 3d., delivered Manchester. West Coast hematite, 73s. 6d. to 74s. 6d. f.o.t.; East Coast ditto, 74s. f.o.t. Scotch, delivered Heysham: Gartsherrie, 70s. 3d.; Glengarnock, 68s. 3d. to 69s.; Eglinton, 67s. 3d.; Dalmellington, 67s. 3d Delivered Preston: Gartsherrie, 71s. 3d; Glengarnock, 69s. 3d. to 70s.; Eglinton, 68s. 3d.; Dalmellington, 68s 3d. Finished iron: Bars, £7 5s.; hoops, £7 17s. 6d.; sheets, £8 7s. 6d. to £8 12s. 6d. Steel: Bars, £7 10s.; hoops, £7 17s. 6d. to £8; boiler plates, official, £8 12s. 6d.; plates for tank, girder, and bridge work, £7 7s. 6d.: English billets, £5 15s. to £6 5s; sheets, £8 12s. 6d.; Copper: Sheets, £116 to £118; tough ingot, £106; best selected, £107 per ton; seamless copper tubes, 14d.; brazed ditto, 13¾d.; seamless brass tubes, 10¾d. to 11d.; brazed ditto, 12d.; condenser, 12d.; brass wire, 10d.; rolled brass, 10d.; brass screwing rods, 9¼d. per lb. Sheet lead, £22 5s. per ton. Tin: English ingot, £198 to £199 per ton.

Lancashire Coal Trade.

There was a fair attendance on the Coal Exchange on Tuesday, and the market, with the single exception of house coal, was decidedly stronger. Demand on shipping account was good, and it was reported that sellers were asking higher prices. For slack and engine fuel generally there is a reluctance to enter into contracts for next year, except at much higher rates than those prevailing for some time past. Furnace and manufacturing coal steady.

BARROW-IN-FURNESS, November 29th.

Hematites.

The improvement noted in the hematite pig iron trade last week has not only been maintained, but further accelerated, a strong demand having set in not only on home but on foreign account, and on American account especially. Some very large transactions are reported, and much more business could have been done had smelters not been so very fully sold forward. As it is, makers are increasing their output in all cases where it is possible to do so, and prices have increased several shillings per ton in consequence of the possible scarcity of iron in the near future. Mixed Bessemer numbers are now very firm at 74s. 6d. per ton net f.o.b., and warrant sellers have advanced their prices to 74s. net cash, buyers 2d. less. The tendency of the market is in the direction of a further advance, and it is thought by some people that 80s. will be reached before Christmas. Stocks have been again increased, and now stand in warrant stores at 75,000 tons. Makers are, of course, holding little or no stock. A good business continues to be done in ferro-manganese on home and on American account, and prices are higher in sympathy with the higher values of ordinary hematite iron. Spiegeleisen is in brisk request on home and foreign account, and the consumption is likely to increase, with the prospect of an increased production at the works in this district where this particular class of iron has generally been produced. A good trade is reported in malleable iron, and some good sales of scrap iron are again reported. Iron ore is in fuller demand, and native sorts are now up to 17s. per ton net at mines, while foreign ores are at 21s., delivered at West Coast ports.

Steel.

The steel trade is much better employed, and the mills in this district are doing more work, but they are idle one day in the week. This is the fact both as regards the Bessemer and the Siemens departments. The demand for rails is still very quiet, and the rail mills have been employed on billets and tin bars when orders have not been forthcoming for rails. Prices have necessarily hardened in consequence of the higher price of iron, and this has resulted in checking new business which would otherwise have been done. Ship plates are in quiet request, and orders are not likely to be large for some time to come. Merchant steel quiet.

Shipping and Coal.

The shipping returns of West Coasts have turned the corner this week; for the first time this year the aggregate is larger than that of the corresponding period of last year. The total export of iron and steel this year has reached 745,710 tons, being an increase of 4369 tons on the corresponding period of last year. Coal and coke are much firmer.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Iron Market—Prices Still Rising.

THE upward movement in the values of irons is firmly maintained. In hematites there is again an advance, West Coast this week being quoted at 82s. to 82s. 6d. per ton, less 2½ per cent., delivered at Sheffield and Rotherham; East Coast, 76s. 6d. to 77s. 6d. per ton net. A sharp rise of 1s. 6d. per ton all round has also been made in the official rates of the Lincolnshire Ironmasters' Association, the quotations now standing thus:—No. 3 foundry, 60s. per ton; No. 4 foundry, 58s. per ton; No. 4 forge, 57s. per ton; No. 5 forge, mottled, white, and basic, 60s. 6d. per ton. The figures given are the highest which have been obtained this year for these classes of iron. The lowest prices were those touched on April 6th, when No. 3 foundry was 52s. 6d. per ton; No 4 foundry, 50s.; No. 4 forge, 49s. 6d.; No. 5 forge, mottled, white, and basic, 53s. Derbyshire makers have practically no stocks to offer, and the quotations remain at 60s. per ton for No. 3 foundry, and 57s. per ton for No. 4 forge. Bars, £7 10s. to £7 15s. per ton; sheets, £9 to £9 10s. per ton.

Steam Coal.

The export business, notwithstanding the lateness of the season, is still active, and demand for prompt delivery has caused prices in some instances to rule considerably over the contract rate, 9s. 6d. per ton having been paid in several quarters. While there is no diminution in local and general requirements for hard coal, the weights sent to two leading foreign markets have considerably increased. The exports from Hull for the week ended November 29th amounted to 68,763 tons, as compared with 40,957 tons for the corresponding week of last year. From Grimsby, for the week ended November 23rd, the exports amounted to 39,425 tons, as compared with 26,474 tons for the corresponding period of last year. Full tonnages of locomotive coal for various continental railway companies are being forwarded. In the open market there is an active demand for steam coal, and prices are readily maintained.

Railway Coal Contracts.

Contracts for locomotive fuel generally extend to the middle of the year. The chief exception to this rule is the North-Eastern Railway, to which company the South Yorkshire coal-owners have delivered their tenders. The price asked for supplies during 1907 is 9s. 6d. per ton, which is an advance of 1s. a ton on the rates now being paid. A year ago the North-Eastern closed with the coalowners at 8s. 6d. per ton, and were the only company to do so at once, other companies standing out against that price until March, when they consented to pay the increase on the condition that the contracts extended over fifteen months. The

tenders sent in from the Northumberland and Durham districts to the North-Eastern are stated to show a considerably larger advance than those given by the South Yorkshire colliery proprietors. The matter is still under negotiation at the time of writing. Whatever arrangement is come to will no doubt practically govern the supplies of steam fuel for the coming season.

Household Fuel.

The continued mildness of the weather has considerably affected the retail business in domestic coal, and stocks are increasing at certain district collieries. The general trade is fairly well maintained. For the small quantity of best Silkstone which is offered the prices asked are 12s. to 12s. 6d. per ton; 10s. to 10s. 6d. per ton for good secondary descriptions. Best Barnsley softs are about 10s. 3d. per ton, lower grades fetching from 9s. to 9s. 3d. per ton in owners' wagons at the pits.

Coking Slack, Smudge, and Coke.

There is no falling off in the demand for coking slack and smudge, nor is there likely to be, the production of coke in the district being so large. Heavy as is the output from the patent ovens, it is certain to be much heavier at an early date. Prices are from 4s. 6d. to 4s. 9d. per ton. Although more manufacturing fuel continues to be raised at Lancashire collieries, there is still a good business done in this locality for the textile districts. The best sorts are quoted at 3s. 6d. to 3s. 9d. per ton at the pits. A fairer tendency is perceptible in coke, in which prices range from 11s. per ton unwashed to 13s. per ton for washed samples. Steel coke is quoted at 23s. to 24s. per ton, delivered in Sheffield.

The Heavy Industries.

Activity is generally reported in nearly all directions, more especially in railway material. The American and German manufacturers being fully engaged in meeting the requirements of their own countries, the competitive factor has largely disappeared. As a result the principal work for railways, with the exception of some good South American orders, is for our own markets at home and at a distance, the Indian demand being particularly gratifying. Our principal steel establishments are full of work, the excellent business in the best qualities with the United States being more than maintained. Bessemer and Siemens steels are also in active request. The engineering houses are well employed. Makers of iron pipes and similar goods have been very busy of late, with every prospect of continued activity. Cooking and heating apparatus for large institutions, hotels, &c., has been in satisfactory request. A revival of activity in the shipbuilding yards is looked for, in which case the light marine forgings and castings department would materially benefit.

John Brown and Co., Limited.

The directors of John Brown and Co., Limited, of Sheffield and Clydebank, at their meeting held at the Atlas Works, Sheffield, on the 27th inst., appointed Sir Charles B. B. McLaren, K.C., the chairman of the company, in succession to the late Mr. J. D. Ellis. Sir Charles, who is actively interested in various important steel, iron, colliery, shipbuilding, and railway undertakings, has been deputy-chairman of John Brown and Co. for a number of years.

Sheffield Company Purchase Welsh Colliery.

Messrs. Cammell, Laird and Co., Limited, Cyclops Steel and Ironworks, Sheffield, have purchased the Clyne Valley Colliery, near Swansea.

NORTH OF ENGLAND.

(From our own Correspondent.)

The General Trade Situation.

The upward movement in the iron and steel industries has this week been more pronounced than ever; it has extended to more branches, and not only have prices increased, but demand has likewise become brisker. As far as regards pig iron the improvement last week was mainly speculative, and was due to the operations in Cleveland warrants, but that being maintained, consumers have recognised that there is a good foundation for the advances, and this has brought them into cover. There has thus been a good deal of buying during the last few days, both on home and export account, and more would have been reported if the makers had been in a position to accept all the orders which the consumers were ready and, indeed, anxious to place. It may now fairly be said that there is decidedly a "boom" in progress such as has not been experienced at any time for more than six years. The rapid upward movement in the early part of last year was due entirely to speculative operations; the current improvement has been brought about largely by increased legitimate business, and is thus sound and healthy. Producers are at present in no hurry to sell for forward delivery, they are exceedingly well supplied with orders for execution over the next few months, and will not commit themselves more heavily in the face of a rising market, and it is generally recognised that the top in prices has not yet by any means been reached. The outlook is encouraging, prospects having improved, not only in the pig iron trade, but also in the finished branches of the iron and steel industries, as well as in allied trades. That is a feature which imparts much confidence with respect to the prospects for 1907. During the last few days advances have been made in the prices of Cleveland pig iron, hematite pig iron, Rubio ore, coke iron and steel bars, sheets, both black and galvanised, rails, and chairs, and the tendency is upward for other descriptions, so that buyers are not inclined to delay arranging for supplies.

Cleveland Pig Iron.

Ironmasters have had a busy time this week in attending to inquiries and booking orders, and consumers have not been disposed to haggle about prices, as they often are in ordinary times. The purchase of Cleveland warrants by consumers has not been so extensive for years, this action being necessitated by the fact that they cannot get from the makers all they need. Rather over a fortnight ago buyers could readily get Cleveland warrants at 56s. 8d. cash, but this week they have had to pay as much as 60s. 4d. cash. The Germans have, in some cases, had to secure Cleveland warrants, like the Americans, as the makers are not in a position to supply all that is required. There can be no question that, though ironmasters have considerably increased their production, there is with them a shortage of pig iron. Both makers and second hands have put up the price of No. 3 Cleveland pig iron to 60s. 9d. per ton, and consumers have paid it. This is a higher figure than has been reported since November, 1900. No. 1 has gone up to 62s. 3d., No. 4 foundry to 59s. 9d., and No. 4 forge to 58s. 6d., and the rapid advance has rather stimulated than checked the demand—in fact, consumers are anxious to buy ahead. Makers undoubtedly at the present time are the masters of the situation.

Hematite Iron.

The most noticeable advance in prices this week has been in East Coast hematite pig iron, there having sprung up a large demand both from Germany and America—indeed, from the latter country it is reported that "the pinch is most severely felt in steel-making iron." Last week mixed numbers of East Coast hematite pig iron could be got at 70s. 6d. per ton; now at least 74s. must be paid for it, and several firms are quoting 75s. The make is hardly equal to the requirements, and if America buys as largely as reports from the other side say she is likely to do, the wonder will be where the iron is to come from. There is no stock from which any can be drawn, none being held in the public warrant stores now, and makers have been cleared out for some time. The advanced prices are partly forced upon the producers by the high rates for materials: they are asked to pay 22s. 6d. per ton for Rubio ore, but as yet have not seen their way to give any such figure. There are merchants who are quoting 24s. and 25s. Any of these rates is considerably more than makers had to give when hematite was last at the present rate, viz., in November, 1900. Then for medium coke the price has risen to 20s. per ton delivered at the Middlesbrough furnaces, a price which was predicted last week.

Stock of Pig Iron.

Makers have scarcely any stock of Cleveland pig iron, and the stock in Connal's public warrants is drawn upon rather heavily for export to America and the Continent. Connal's on 28th held 554,235 tons of Cleveland pig iron, a decrease of 23,240 tons, and of 195,860 tons since the stock began to decline last March. The stock consists of 534,608 tons of No. 3, and 19,627 tons of No. 4 foundry.

Exports of Pig Iron.

Last month's exports of pig iron from the Cleveland district were the best of any month on record, but this month the shipments are still larger, supplies being rushed away to Germany at an extraordinary rate. If the deliveries continue to go on at such a brisk rate Connal's stock must decline even more rapidly. The output of the district is about at its full capacity. The shipments have this month been 125,612 tons, as compared with 118,728 tons last month, 75,413 tons in November, 1905, and 62,802 tons in November, 1904, all to 28th.

Cargo Fleet Blast Furnaces.

On account of ill health, Mr. John Ward, who has been for years manager of the blast furnaces of the Cargo Fleet Iron Company, at Cargo Fleet, near Middlesbrough, has resigned that position, and he is succeeded by Mr. Emil Jogsch, who has been blast furnace manager at the Konigshütte Works, in Upper Silesia, Germany, where he has had much experience in making basic iron from low grade ores.

Realised Prices of Finished Iron.

On behalf of the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England it has been ascertained that the average price realised by the manufacturers for the finished iron delivered by them during the two months ending October 31st was £6 12s. 11·47d. per ton, an increase of 3·55s. on the average for the previous two months. Wages at the mills and forges, therefore, for December-January will continue the same as in October-November. The rate for puddling is 8s. 9d. per ton, or 9d. increase this year, and other wages have this year risen 7½ per cent. This year the realised price has been advanced 9s. 5d. per ton, and it is nearly 13s. better than in September-October last year. The present rate is the best that has been reported since May-June, 1901, since when the figure has been down to £5 16s. 5d. in November-December, 1904, and the rise from that has been 16s. 6d. per ton. As compared with the July-August return, the value of iron rails has declined about 1d. per ton, that of plates improved 2½d., that of bars—which form three-quarters of the make—decreased 1½d., and that of angles rose 8·37d. per ton.

Manufactured Iron and Steel.

The improvement which is noticeable in several branches of the finished iron and steel industries is very satisfactory, and has increased confidence. There is a distinct revival in the demand, and prices are moving up. Bars have this week gone up 5s. per ton, sheets 5s., galvanised sheets 10s., rails 2s. 6d, and chairs 2s. 6d., and it is expected that quotations in other branches will likewise be advanced. Common iron bars are now at £7 10s., best bars at £8, and best best bars at £8 10s. These show a rise of 10s. per ton this year. Sheets—singles—are up to £8 10s., less 2½ per cent. Extensive sales of galvanised sheets are reported, and the works producing them are employed to their fullest capacity. Buyers have to pay at least £13 5s., less 4 per cent., per ton for 24 gauge in bundles f.o.b The demand for steel rails is becoming decidedly brisker, and producers are now asking £6 7s. 6d. net f.o.b., while for steel railway sleepers £7 net is the figure, and for cast iron chairs £3 17s. 6d. net. An advance in plates is generally looked for; no alteration in the quotation for these has been reported since October of last year.

Shipbuilding.

Somewhat better reports are given by shipbuilders. Shipowners see that prices of new vessels are not soon likely to be lower. The settlement of the strike on the Clyde has not yet been followed by the termination of that on Teesside. It is stated, however, that the representatives of the men are formulating an arrangement which will probably meet with the favourable consideration of the employers. Another conference is to be held, at which the matters in dispute will be compromised, and work will not unlikely be resumed early in December. It is not the desire of the employers that the men should be worse off than those on the Clyde, but they do not want to continue, as heretofore, to pay more for labour than their competitors in other districts.

Coal and Coke.

The coal trade continues very active, the demand being so good that the collieries can hardly satisfy it. It is extraordinarily good on export account, and it is expected that before long the Americans will be buying British coal, for there are inquiries from the United States. For coking coal 11s. 6d. per ton can now be realised, and that makes coke dearer. At least 20s. per ton must now be paid for medium coke delivered at Middlesbrough furnaces.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General Condition of Trade.

THERE has been a better feeling in trade generally since the settlement of the strike in the shipbuilding industry. That arrangement has not so far been followed by any marked improvement in the demand for new vessels. The high prices of all kinds of material act as a strong deterrent to fresh enterprise, only contracts of a pressing nature being entered into at the present time. It is possible, however, that, if the turn of the year brings cheaper money, a fresh expansion may come in various departments.

Continued Foreign Demand for Pig Iron.

The inquiry for pig iron for the United States has shown little or no abatement since last report. Considerable additional sales appear to have been made, and every day brings its quota of inquiries, more or less urgent, as to the time of delivery and the prices at which pig iron can be supplied. It is stated that in some cases makers have been asked to guarantee delivery, and name their own terms. But there appears to be an indisposition on the part of both merchants and makers to enter into large forward obligations. Orders are said to have been arranged to supply pig iron up to the middle of next year. The inquiries from Canada and the Continent are also important and pressing, and there has been a further material advance in prices.

Prices of Scotch Makers' Iron.

Since last report the values of Scotch makers' pig iron are generally advanced 1s. to 2s. per ton. G.M.B., No. 1, is quoted at Glasgow 67s.; No. 3, 64s. 6d.; Govan and Monkland, Nos. 1, 67s. 6d.; Nos. 3, 65s.; Carnbroe, No. 1, 69s.; No. 3, 66s.; Clyde, No. 1, 71s. 6d.; No. 3, 66s. 6d.; Gartsherrie and Calder, Nos. 1, 72s.; Nos. 3, 67s.; Langloan, No. 1, 73s.; No. 3, 68s.; Summerlee, No. 1, 74s.; No. 3, 68s. 6d.; Coltness, No. 1, 82s.; No. 3, 68s.; Glengarnock, at Ardrossan, No. 1, 72s.; No. 3, 68s.; Eglinton, at Ardrossan or Troon, No. 1, 86s.; No. 3, 65s.; Dalmellington, at Ayr, No. 1, 70s.; No. 3, 65s.; Shotts, at Leith, No. 1, 72s.; No. 3, 67s.; Carron, at Grangemouth, No. 1, 73s.; No. 3, 68s. per ton.

Foundry Iron and Hematite.

A large proportion of the iron now being purchased on foreign account is reported to be for foundry use, and the qualities suitable for that purpose have been steadily advancing in value. There is also a steady demand for hematite for export, which has come opportunely, when there is not likely to be so much wanted at home for shipbuilding purposes. Sales of Cumberland hematite pigs have taken place up to 73s. per ton, and Scotch hematite is at 73s. 6d. for delivery at the West of Scotland steel works. The increasing demand for hematite ore is making the price very onerous, 17s. per ton being mentioned as the rate quoted at Bilbao.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week are returned as 11,049 tons, compared with 3974 in the corresponding week of last year. Of the total amount, 1280 tons were despatched from the East Coast, 6200 tons at Glasgow, and 3660 at Ayrshire ports. To the United States 4275 tons were despatched; Italy, 2800; Canada, 415; South America, 290; India, 280; Holland, 170; France, 151; Germany, 145; Australia, 75; Belgium, 90; other countries, 220; the coastwise shipments being 2138 tons, compared with 2238 in the corresponding week of 1905. The total shipments for the year to date are 30,000 tons better than at this time last year.

The Warrant Market.

A large business has been done in pig iron warrants, Cleveland iron being fully 2s. per ton higher than a week ago. Prices at the time of writing are 60s. 1½d. to 60s. 2½d. for cash, 60s. 7d. for delivery in twenty-seven days, and 60s. 8d. one month. Prices have been about 6d. a ton above the rates since last report, and the market is subject to fluctuations owing to speculators taking profits, and others, in their turn, operating for a further rise in values.

Finished Iron and Steel.

A somewhat better demand is reported for malleable iron, home users coming forward more freely, and the makers are now in a better position than for a considerable time. The competition for export is very keen, and it is reported that by cutting rates the Belgians are securing the bulk of the foreign trade in finished iron. There is a very good business in steel bars, both for home use and export. Ship and boiler plates, especially the former, are quiet, but an early improvement is expected. The demand for structural steel for abroad has been steadily increasing.

The Shipbuilding Trade.

Since the termination of the strike there has not been much fresh business reported, although rumours are current that a few contracts are likely to be given out soon.

The Coal Trade.

It is not surprising that there should be an occasional decrease in the coal shipments, considering the large quantities despatched immediately before and after the abolition of the export tax. The past week's coal shipments from Scottish ports were 265,244 tons, being 27,860 tons less than in the preceding week, but still 16,399 tons more than in the corresponding week of last year. For the present year to date the shipments aggregate 12,587,603 tons, being 1,333,744 tons more than in the same period of 1905. House coal has been quiet, owing to the very mild weather. Prices of all kinds of coal are practically unchanged.

Oil Pipe Line for Burmah.

Great interest is being taken in the proposed oil pipe line in Burmah to which I referred in a recent letter, and it is hoped that the whole, or, at any rate, a large part of the order may be secured in this country. British tube makers are asserting, with a great deal of reason, that they have at least as much experience of this class of work as American makers, and one firm is pointing to the work it did as much as thirty years ago in Russia. Probably few people are aware of the enormous amount of pipe that is turned out annually by British makers for purposes of this kind.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal, Coke, and Patent Fuel.

THE exports abroad from the South Wales ports continue to show an improvement, and for the week ending the 23rd inst. I notice an increase of 190,000 tons over the corresponding week of last year. This was most marked at Cardiff, which indicated an increase of nearly 150,000 tons. Newport and Port Talbot made up the balance, but Swansea, by reason of deficient tonnage, due to the storms, showed a decrease of 5000 tons. Trade with the East would appear to be improving. Cardiff, last week, sent two cargoes to Aden, one to Bombay, and three to Colombo. Last week Cardiff's best customers were the River Plate, with ten cargoes of nearly 38,000 tons; and Port Said with six cargoes, totalling nearly 30,000 tons. Newport's principal customer was Venice, with some 10,000 tons. Swansea sent most of her cargoes to the North French and Bay of Biscay ports.

Condition of the Coal Market.

On 'Change, Cardiff, it was the comment generally that prices were very irregular, owing to the fact of some collieries being well supplied with orders, and others, through non-arrival of tonnage, being anxious to sell at less than market price, in order to get coal-laden wagons tipped. It will readily be inferred from this that prices greatly depend upon the position of buyers' tonnage. I have heard of several low prices for spot shipment. Latest quotations at Cardiff are as follows:—Best large steam, 15s. 6d. to 16s.; best seconds, 15s. to 15s. 6d.; seconds, 14s. 6d. to 14s. 9d.; drys, 14s. 3d. to 14s. 6d.; best washed nuts, 12s. 6d. to 13s.; seconds, 11s. 6d. to 12s.; best washed peas, 11s. 6d. to 11s. 9d.; seconds, 10s. 6d. to 10s. 9d.; very best smalls, 9s. 9d. to 10s., easier, but recovering; best ordinaries, 8s. 3d. to 8s. 9d.; seconds, 8s. to 8s. 3d.; inferiors, 7s. 3d. to 7s. 6d. Monmouthshire semi-bituminous: Best large, 14s. 3d. to 14s. 6d.; best ordinaries, 14s. to 14s. 3d.; seconds, 12s. 9d. to 13s. 3d.; inferior, 12s. to 12s. 6d. House coal, best, 16s. to 16s. 6d., demand improving; best ordinaries, 13s. 6d. to 14s. 6d.; seconds and other kinds, 11s. to 13s.; No. 3 Rhondda, 16s.; brush, 13s. 3d.; smalls, 11s. to 11s. 3d.; No. 2 Rhondda, 12s. to 12s. 6d.; through, 9s. 6d. to 10s.; smalls, 8s. to 8s. 3d. Coke 17s. to 18s. furnace, 22s. to 30s. for foundry; trade brisk. Patent fuel: Improving, 15s. 3d. to 15s. 6d. Pitwood: Prices are well maintained, owing to scarcity of arrivals. A considerable quantity of wood is understood to be on passage, and collieries are hopeful of being able to trade towards the end of the week considerably below present prices. Merchants remain optimistic, and state that figures will remain as at present for some time. Latest

quotations, Cardiff, 27s. 6d. to 30s. Exchange quotation, Tuesday, was 15s. to 16s.

The Anthracite Coal Trade.

At Swansea this week anthracite coal was principally in demand, and a fair amount of business done. Big vein and red vein are in good demand, and for beans and peas supply is a long way behind requirements. Latest figures:—Best malting, 20s. to 21s. 6d.; seconds, 16s. 9d. to 17s. 9d. big vein, 15s. 6d. to 16s. 6d.; red vein, 11s. to 12s. 6d.; cobbles, 18s. to 18s. 6d.; nuts, 22s. to 23s.; peas, 14s. to 14s. 6d.; rubbly culm, 6s. to 6s. 6d.; duff, 5s. to 5s. 6d. Other quotations are:—Steam coal, 15s. 6d. to 16s. 6d.; No. 3 Rhondda, 15s. 6d.; bunkers, steam, 11s. to 11s. 6d. Patent fuel, 13s. to 13s. 6d., easier.

Llanelly Coal Trade.

A link with Monmouthshire coalowners was formed this week by the purchase of the Port Henry Colliery by the Bargoed Coal Company. This has been the subject of satisfactory comment this week, it being understood that considerable developments are to be carried out. Llanelly industries are all busy. Large increase of trade is taking place with San Francisco and Russia.

Resumption of Work by the Colliers.

I am pleased to see that the resumption of work has been steadily going on. On Monday the Penrhiwkiber colliers resumed work after a stoppage of three weeks. Alarmist fears are now quite allayed, and though there is still some little disquietude in one or two places, and notices are threatened, the prospect of steady work for the winter is assured.

Freights.

At Cardiff, this week, it was stated that, owing to congestion of traffic in several of the Italian ports, and consequent delays to tonnage, freights have shown considerable improvement; as much as 8s. 3d. has been paid for Genoa. Rates for Mediterranean are firm; South America and Islands steady; Bay and coasting quiet. Some high rates have been paid by pitwood merchants who have cargoes to lift—as much as 8s. 9d. from Bayonne to Swansea.

The Albion Explosion.

It has long been a disputed question with colliery authorities whether or not the electric light was safe in the midst of explosive gas; and now the jury in the case of the Albion Colliery explosion, by which six lives were lost, have decided that it is not to be thoroughly trusted. At the adjourned inquest held this week the jury accepted the belief of mining experts, and attributed the explosion to electric spark. It is interesting to note that since the explosion which occurred on Sunday night, November, 1896, in the Maindy Colliery, when there was no one in the pit, and the exhaustive experiments of Mr. Heppell since, attention has been keenly directed to the action of "falls," which in the present case was the first predisposing cause, and now with the collective evidence following, more safeguards have been obtained against these deplorable occurrences. In "Talk of the Hill" a park from the blacksmith's forge was the supposed cause.

The Tredegar Ironworks.

At Deighton Works, Tredegar, new and modern plant for the manufacture of hoop steel is likely to be placed. Mr. Whitehead, one of the proprietors, returned lately from a visit to the United States, where he inspected the most successful mills, and at a banquet given him on his return, gave an interesting account of his examination into the latest methods and manufacture, which far excel anything, he thought, in this country; and he proposes a thorough adoption of the patents, and a considerable outlay. This announcement has awakened the greatest interest, and it seems probable that a new era is likely for the district.

Iron and Steel Trade.

In iron and steel circles the boom experienced in the Midlands is expected to have its effect here. In all the leading works a satisfactory condition prevails. Imports and dispatches have been numerous. Pig iron has come in freely from Barrow, Harrington, and Grimsby, and one cargo of steel billets, 2033 tons, to Newport from New York. Among the chief consignments have been:—615 tons steel rails to India from Cardiff, a cargo of galvanised iron to Valparaiso, and another cargo of rails, 1400 tons, with 222 tons of black sheets, for Calcutta. Newport sent 500 tons rails to Liverpool. Pyle received 2000 tons manganese. On the Metal Exchange, Swansea, quotations were given out as follows:—Pig iron: Bessemer, mixed numbers, 73s.; Middlesbrough, 60s.; Scotch, 65s. Welsh hematite, 79s. to 80s. Siemens, steel bars, rom £5 17s. 6d.; Bessemer, from £5 17s. 6d. Heavy rails: Prices steady; prospects of an advance. Heavy sections, £6 7s. 6d. to £6 10s.; light sections, £6 12s. 6d. to £6 15s. Other quotations are:—Block tin, £197; lead, £19 15s.; copper, £101 15s.; spelter, £28; silver, 32 1/16d. per oz., all active. Iron ore is very firm. Large cargoes are coming into Newport and Cardiff. Prices:—Rubio, 21s. to 22s.; Tafna, 22s. to 23s.; Almeria, 21s. to 21s. 6d. c.i.f. Newport.

The Tin-plate Trade.

The volume of business continues satisfactory in all quarters. A few mills under repair lessened the make at Swansea last week, but the evidence of trust work was shown by the total sent from works — 76,061 boxes. Shipments were also large, 80,915 boxes, leaving stocks at 134,119 boxes. One of the leading requirements was 19 × 14 C. 18¾ × 14, and C. 28 × 20 g. 32 and down to 36 gauge. The advance of steel, and firmness of both kinds of bars, tell on quotations:—Bessemer primes, I.C. 20 × 14, 112 sheets, 100 lb., are at 15s.; wasters, 14s.; Siemens primes, 15s. 1½d.; wasters, 14s. 1½d.; C.A. roofing sheets are £11 10s. per ton; big sheets for galvanising, £11 12s. 6d. to £11 15s. Finished black plates, £11 5s. per ton. Llanelly is well employed, and the general condition of the trade in all quarters good.

Royal Commission on Shipping Rings.

A good deal of satisfaction was expressed at the Welsh ports this week by the announcement that Sir W. T. Lewis, Bart., had been added to the Royal Commission. This will make the seventh upon which he has acted from the earliest—that of the Commission upon Coal Mines.

NOTES FROM GERMANY.

(From our own Correspondent.)

The Iron Market in Rheinland-Westphalia.

DURING the past week a good number of fresh orders were received, and the amount of fresh work is so heavy at some establishments that contracts for immediate delivery had to be refused in a few instances. A further upward tendency in prices could be noticed for several articles, and the physiognomy of the iron market is bright on the whole. The number of contracts secured by the Steel Convention in the middle of October amounted to 3,686,000 t. In the plate and sheet department employment and inquiry are excellent, and activity during this and the next quarter will be strong. An advance in quotations is expected to take place shortly.

Iron and Steel in Silesia.

At the various mills and forges an exceedingly brisk activity continues; the scarcity in raw material is felt more keenly than ever, and there is but little likelihood of an improvement in this direction, as the additional blast furnaces that are in course of construction at three of the principal ironworks in Upper Silesia cannot be finished as soon as was expected. All descriptions of building material continue in urgent request; the girder mills have to ask very long terms of delivery, and stocks have dwindled down to a mere nothing. The same is the case with sectional iron, and the mills are looking forward to being busy even during the usually quiet and somewhat dreaded winter months, as next year's building season is generally expected to be lively.

Coal and Coke in Germany.

In Silesia the prices for coal for consumption in Germany have met with an advance of 0·60 p t., while for Austrian consumption a rise of 0·10 pf. p.t. only takes place. Demand continues extensive, and the scarcity of wagons is, therefore, all the more keenly felt. Much the same can be said of the Rhenish-Westphalian coal industry. The low water of the Rhine had considerably restricted deliveries in coal to South Germany, but recent rain has improved matters.

The Austro-Hungarian Iron Market.

The position generally has remained unaltered. In a few instances an increasing demand could be noticed, and employment in all branches is exceedingly brisk. The scarcity of wagons threatens to become a serious trouble to the iron industry. Regarding the different departments, there has been an uncommonly good business done in pig iron. The works are very briskly occupied, and steel deliveries are rather lower than consumption. In the manufactured iron department an excellent demand comes in for plates and sheets, and bars and girders are also well inquired for. The prices of sale remain comparatively low, and are not in proportion to those of the raw material, and the profit is small consequently. The rise in the price for Silesian coal will have a marked influence on the Austro-Hungarian coal market, for nearly the total supply in house coal is imported from Upper Silesia, and the quotations for Upper Silesian coal, therefore, regulate those for the Moravian-Ostrau district. Ironmasters continue to complain of the scanty supplies in fuel, and English coal is reported to have been bought in some instances. Austrian coal dealers are also said to have sent representatives to Russia for the purpose of securing supplies from there, but the coal that has been got is reported to have been very dear and of inferior quality, besides only two wagons have been obtained where fifty were wanted. On the Bohemian brown coal market numerous orders have been coming in from districts that have, perhaps, never before bought Bohemian brown coal—Hungary, for instance, and Russia, the German briquette-making districts, and Silesia; but all these orders could not be taken, as the want of wagons prevents a regular supply even to local consumers.

Steady Trade in Belgium.

The rapid upward movement in quotations on the Belgian iron market has been followed by a slight quieting down in several branches. Inland as well as foreign orders come in regularly, and the business transacted is satisfactory, if not quite as vigorous as some weeks ago. An upward movement can be noticed in the prices for coal in Belgium, and the new year is likely to bring an advance of 1f. to 2f. p.t. Coke is in animated request at rising quotations.

The French Iron Business.

Full employment is secured to all the principal establishments by a number of contracts of fair weight. The tone all round is healthy and firm, and producers are reported to intend an advance of 2f. to 2·50f. p.t. for several sorts of iron later on. At present quotations for iron are somewhat influenced by those for coal. The latter have been on the whole improving, as the demand for all sorts of fuel is very active.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, November 14th.

Owing to the enormous buying in pig iron that has been going on for months past buyers have withdrawn from the market, having very generally made ample provision for periods ranging from a few weeks to several months It is estimated that the requirements for foundry iron for the first quarter of next year have been covered to at least 25 per cent., and most of the buyers are disposed to delay further purchasing on account of the pronounced upward tendency, which they claim to believe is not warranted. A good deal of foreign iron is coming in. A number of transactions have been closed for the shipment of English and Scotch grades, and these purchases will probably assume considerable proportions. The consumers of basic iron have been unable to place the orders which they have been trying to place, and they are still awaiting answers from makers of basic. Just at present there is a dulness throughout the crude iron and steel industry owing to the fact that prices have gone a little too high and consumers are simply awaiting developments. Basic iron has gone beyond the limit. There will be no demand for it eventually, and consumers will be obliged to pay the high prices sooner or later. With regard to finished material, the requirements of the country seem to be as urgent as ever. This is particularly true with reference to rolling stock, locomotives, bridge iron, steel rails, and other material for construction purposes. The requirements of the rail companies appear to be increasing rather than declining, notwithstanding more rails have been contracted for this year by far than last year, and the orders for rolling stock are at least double the orders of any former year. At the present time the steel and wooden car builders are figuring upon a great deal of work, the contracts before the car builders to-day calling for 12,000 cars and upwards of 300 locomotives.

The larger bridge building requirements have been covered, and makers are now trying to clear up the small ones. The American Bridge Company is averaging business of over 2000 tons of material per day. A large building in Chicago called for 10,000 tons of structural material. Rail contracts have been placed this week aggregating 35,000 tons. There are two large contracts for rails which will go through before Saturday. One will be placed in Pennsylvania, the other in the Illinois steel rail mill, each for 30,000 tons. Slight advances are being made in minor products, such as hoops, which have been advanced 2 dols. per ton, and in bar iron. The bar mills are booking orders for spring delivery for car building purposes, and the sheet mills are also booking business for spring delivery, mostly for heavy sheets.

Our only escape is a greater dependence upon English and Scotch irons. Sales were made yesterday at prices ranging from 23·50 dols. to 24 dols. for Scotch and 22 dols. to 22·50 dols. for English iron at tidewater. Prices generally on foreign irons are from 50 c. to 1 dol. a ton higher than a week ago. In the Boston territory Middlesbrough iron has sold as high as 25 dols., delivered, and Scotch as high as 27 dols.

The lead production for 1905 was 302,247 tons, which was 5000 tons less than the previous year. Refined copper is quiet at present, and Europe appears to be getting more metal from Japan and Australia.

LIVERPOOL ENGINEERING SOCIETY.—The annual dinner of the Society will take place on the evening of Thursday, the 17th January, 1907.

NEW ARGENTINE RAILWAYS.—It is announced that the Argentine Government have resolved to carry out the construction of the following lines, already sanctioned by Congress:—Cordoba to Rio IV. with branches to Huinca Renancó and Los Reartes, at a cost of £2,080,000, and two branches in the province of Tucuman, one from Las Cejas to Antillas, a distance of 40 kilomes., at a cost of £371.762, and another from Rincho to Santa Rosa of 19 kiloms., at a cost of £65,139.

FATAL RAILWAY COLLISION AT ULLESKELF.—On Saturday evening last, the 24th instant, a collision occurred at Ulleskelf, between York and Normanton, on the North-Eastern Railway. There are four lines of way between York and Church Fenton, an up and down for Leeds and an up and down for Normanton. A train of empty mineral wagons was standing on the line to Leeds, along which the 5.55 p.m. from Scarborough to Leeds should have travelled. The signalman at Bolton Percy—the signal box in the rear—therefore arranged to turn the Leeds train on to the Normanton line, so that it could run round the mineral train. The Normanton line was, however, required for an approaching Lancashire and Yorkshire express, so that the signalman kept his signals at danger against the Leeds train. For some unexplained reason the driver did not pull up, but continued his journey, and passing five signals at danger came into collision with the train of empties. Whether the driver's neglect was due to the signals being hidden by a fog that prevailed, or by the steam from the Lancashire and Yorkshire engine, cannot at present be stated, and as the unfortunate driver and his fireman both lost their lives, this may not be cleared up. There were practically no casualties to passengers, but the engine was seriously damaged, and the brake van and some trucks of the mineral train were injured. More light may be thrown on the cause at the adjourned inquest next Tuesday.

ROYAL METEOROLOGICAL SOCIETY.—At the meeting of the Royal Meteorological Society on Wednesday evening, Mr. W. Marriott read a paper on "The Abnormal Weather of the Past Summer, and Some of its Effects." The principal features of the weather over the greater part of England—especially the south-east—were the high state of the barometer throughout the whole of the period, except a portion of August; the high temperature in July, August, and September; the great amount of sunshine; and the deficiency of rainfall. Over the south-eastern portion of England more than 900 hours of bright sunshine were recorded during the four months June to September; while at a few stations in the extreme South and on the East Coast over 1000 hours were recorded. The sunshine was more than 200 hours above the average over the Thames basin and on the coasts of Lancashire and North Wales. The most remarkable feature of the weather during the past summer was the exceptional heat wave which occurred between August 30th and September 3rd. The temperature rose above 90 deg. over a large part of England on four consecutive days, viz., August 31st—September 3rd. Mr. Marriott has not been able to find any previous record of readings over 90 deg. for a similar period. The air was very clear, and brilliant sunshine prevailed over nearly the whole of the country. Another remarkable feature connected with this heat wave was the great dryness of the air; for on September 1st and 2nd differences of 25 deg. were observed between the readings of the dry and wet bulb thermometers, and relative humidities below 30 per cent. were recorded at many inland places.

NORTH-EASTERN RAILWAY COAL CONTRACT.—The North-Eastern Railway coal contract for the ensuing year is now in the market and is creating unusual attention. The contract, which supersedes those falling out at the close of December, is one of the largest and most important of the year. The acceptance of the contract usually fixes the prices to be paid not only for locomotive but for shipping fuel. During the week tenders have been sent in by the South Yorkshire Associated Thick Seam Collieries at 9s. 6d. per ton, being 1s. per ton advance on the expiring rates last November. The coalowners were asked to tender for three, six, or nine months. Tenders were sent in at the rate of 8s. 6d. per ton for the first half, 9s. for the second half, or 8s. 9d. per ton for the whole twelve months. The Great Northern and Great Central offered 8s. 3d. per ton, which was promptly declined. The North-Eastern accepted the tender at 8s. 6d. per ton for the twelve months, but the Midland broke away and placed several contracts outside the federate area for what was held to be secondary samples of steam coal. A compromise was subsequently effected, and tenders were placed at 8s. 6d. per ton for fifteen months, so that the most important do not fall out until the end of June next. Generally speaking, South Yorkshire coalowners have refrained from placing shipping contracts for last year, owing to so large a portion of the output being locked up to the end of the half-year. They contend that the abnormal state of the steam coal trade during the last few months justifies them in asking for the advance, seeing that prices have of late ruled at 1s. per ton advance of railway rates. What course will be adopted remains to be seen. As stated, the contract is a valuable one to coalowners, the company finding its own wagons, whilst payments are always prompt and business relations of an amicable nature.

CONTRACTS.—Among recent contracts obtained by the Brush Electrical Engineering Company, Limited, of Victoria Works, Belvedere-road, S.W., may be mentioned one for the overhead line equipment of the Tipton section of South Staffordshire tramways. One for the overhead equipment of College-road and Stratford-road section of the Birmingham tramways. A contract from the India-office for the electrical installation of Bari Doab Irrigation Canal, Punjaub; and an order for four postal vans with bogies complete for the Soudan State Railways.—The directors of the Glasgow and South-Western Railway Company have accepted the offer of Messrs. James A. Millen and Sommerville, Tradeston Ironworks, Glasgow, to carry out the work in connection with their new wagon and paint shops at Barassie, consisting principally of structural steel work. The contract has to be completed and the buildings ready for occupancy within nine months.—Owing to the economy obtained, the Blyth Harbour Commissioners have ordered another rock-breaking plant from Lobnitz and Co., Limited, duplicate of the first machine, to be built under the direction of Messrs. J. Watt Sandeman and Son, of Newcastle-on-Tyne, engineers to the Blyth Harbour Commission.—We learn that the Linolite Company, of 25, Victoria-street, S.W., has just despatched 1000ft. of linolite to their agents in Bombay, in fulfilment of an order placed with them in connection with the coming visit of the Ameer of Afghanistan to India.—We are informed that Pollock and Macnab, Limited, of Bredbury, Manchester, have received an order for machine tools for car shed equipment for the Birmingham Corporation tramways.—The Kennicott Water Softener Company, of 18 and 19, Great St. Helens, E.C., has received an order from the Earl of Dudley's Round Oak Steel Works, Limited, of Brierly Hill, Staffordshire, for a machine of 20,000 gallons an hour capacity.—Crompton and Co., Limited, have just received an order from the United National Colliery Company, Limited, Cardiff, for thirteen of the firm's standard three-phase induction motors, 600 volts, 25 cycles, aggregating 230 brake horse-power.—Messrs. Bruce Peebles and Co. have received a further motor converter order from Messrs. Hubert Davies and Spain.—Handley and Shanks, of Birmingham, are carrying out the complete electric lighting installation for the new works of the Enfield Cycle Company, Limited, at Redditch.—Messrs. George Cradock and Co., of Wakefield, have recently received orders from the De Beers Consolidated Mines, Limited, for 21,920ft. of 5in. circumference best plough steel winding ropes and for eight miles of haulage ropes. On the Wesselton Shaft a pair of Cradock's 5in. ropes raised 1,746,370 loads in eleven months, this being a record at these mines. On the Whiting hoist engine at Kimberley Shaft one of the firm's 5in. ropes raised 565,406 loads.—Ernest Newell and Co., Limited, of Misterton, Gainsborough, have this week received orders for four of their "Robeson" type tube mills for the South African goldfields.

CATALOGUES.

JOHN DUGDILL AND Co., Failsworth, near Manchester.—Electrical fittings.

MATHER AND PLATT, Limited, Manchester. — "D" type dynamos. Fourth edition.

ROBERT STEPHENSON AND Co., Limited, Darlington.—"Notes and Illustrations of Recent Work," October, 1906.

JAMES WALKER AND Co., Garford-street, West India Dock-road, London.—Catalogue of "Lion" packing materials.

JOHNSON AND PHILLIPS, Limited, Charlton, Kent.—Price list J. Feeder pillars, switch pillars, and junction boxes, &c.

C. L'ESTRANGE EWEN, 45, Hope-street, Glasgow.—Circular of illustrations of some recent motor boats designed by Mr. Ewen.

GENERAL ELECTRIC COMPANY, Limited, 71, Queen Victoria-street, London.—Section "S," 1906, sale list is devoted to electric lighting accessories.

LUDW. LOEWE AND Co., Limited, Farringdon-road, London.—In a pamphlet entitled "Water Sterilisers" is described Hartmann's water purifying system.

JAMES B. PETTER AND SONS, Limited, Nautilus Works, Yeovil.—The Petter patent oil engine applied to stationary purposes or portable, or as a tractive agent, is described and illustrated in this catalogue.

BRUCE PEEBLES AND Co., Limited, 1, London Wall-buildings, London, E.C. Pamphlet No. 19: Turbo Alternators.—This pamphlet describes in detail the construction and characteristics of Peebles turbo alternators.

THOMAS ROBINSON AND SON, Limited, Rochdale.—Catalogue Series 8, Section IV., is devoted to saw benches, band saws, and fret saws. A word of praise is due to the excellent manner in which the book is got up.

BALDWIN LOCOMOTIVE WORKS, Philadelphia, U.S.A.—Record of Recent Construction, No. 59, 1906, shows various types of locomotives, including the Pacific, Prairie, Consolidation, ten-wheel balanced made for American railways.

JOHNSON SERVICE COMPANY, Milwaukee, U.S.A.—We have received a pamphlet from this firm describing the Johnson system of temperature regulation. The system depends for its operation upon compressed air, which operates the valves and dampers.

LONDON DRAWING AND TRACING OFFICE, 98, Gray's Inn-road, W.C.—A very neat booklet just published by this firm is devoted to models of buildings, estates, works, &c., suitable for exhibitions and actions at law. Judging from the illustrations the models are most effective.

BRITISH PROMETHEUS COMPANY, Limited, Highgate, Birmingham.—Electric convectors and radiators are dealt with very fully in this catalogue. The designs are quite pleasing in most cases, and we are informed that in efficiency and durability the apparatus leaves nothing to be desired.

MATHER AND PLATT, Limited, Manchester.—Eighth edition of steel-clad electric motor catalogue. The design, as shown in the illustrations, is compact, the magnet casting forming a case which protects all parts from injury. The shaft centre is low; the bearings are long, and are fitted with automatic ring lubrication.

ADJUSTABLE COVER AND BOILER BLOCK COMPANY, Limited, Friar-street, Reading.—This booklet contains designs of blocks and covers for the setting of steam boilers. The makers claim that these blocks adapt themselves to the expansion and contraction of the boiler, while inspection is facilitated.

MATHER AND PLATT, Limited, Manchester. Third edition of steam engine catalogue.—The contents include specifications of open type compound engines ranging in power from 50 to 1000 indicated horse-power. The book also includes particulars of vertical mill engines, &c., and is produced in a tasteful manner.

R. J. NICHOLSON AND Co., Macdonald's-lane, Corporation-street, Manchester.—"Light in the Country" is the title of a pamphlet, and, amongst other features, contains an illustrated description of the "Ideal" electric outfit, comprising a combination of petrol engine, dynamo, storage battery, switchboard, &c. The book is neatly produced.

JOHN LANG AND SONS, Johnstone, Glasgow.—This is a new lathe catalogue, and its production is very creditable. In addition to the usual run of lathes there are also included in this catalogue illustrated particulars of Lang's variable speed drive for lathes, boring and tapping machines, tool sharpeners, &c. The illustrations are well produced.

PERTWEE AND BACK, Nelson Ironworks, Great Yarmouth.—The "Nelson" ice crusher forms the subject of this pamphlet. These machines are constructed on a new principle throughout, and are the result of long practical experience. They are fitted with toothed rollers, the teeth of which are made of special steel with square taper shanks, and are secured with nuts, making it impossible for them to turn round out of their correct positions and become loose.

PRATT'S PATENT MANUFACTURING COMPANY, Albert Works, Dukinfield, Cheshire.—Circulars describing Pratt's silencers for oil, gas, and petrol engines. The operation of this silencer is described as follows:—The exhaust gas on leaving the engine enters the silencer and passes through holes into an outer chamber, forcing discs forward against the action of springs, thus causing the chamber to enlarge or expand. The reaction of the springs will gradually force the discs back again as the gas passes through them. The gas then passes through the holes at the outlet end into a central tube and proceeds along this tube towards the inlet end, then through the holes in the inner tube towards the outlet, and into the atmosphere.

AMERICAN LOCOMOTIVE COMPANY, 111, Broadway, New York.—Consolidation type freight locomotives. A pamphlet published by the above company describes and illustrates a large number of Consolidation locomotives built for various railways. This pamphlet includes only Consolidation locomotives weighing less than 175,000 lb., and will be followed shortly by a pamphlet illustrating designs of this type weighing more than 175,000 lb. The pamphlet opens with a description of the 2-8-0 type, giving its distinguishing characteristics and its special advantages for heavy freight service or service on light rails where the wheel load is limited. Then follow four pages of tables giving the principal dimensions of thirty Consolidation locomotives ranging in weights from 66,000 lb. to 175,000 lb., the tables being arranged in the order of the total weights of the locomotives. Other pages show drawings of the side elevation and end elevation of a typical design of Consolidation locomotive.

DRUMMOND BROS., Limited, Ryde-hill, near Guildford.—Two pamphlets describing two small lathes. The first is a 3½in. gap lathe suitable for model and accurate small work. It has back gear and full screw-cutting gear. The lead screw is in the centre of the bed which, is 2ft. 6in. long. This screw gives also the traverse to the saddle, which is fitted with a simple removable slide rest. The poppet head swings over for taper work, and the spindle has a ⅜ hole through it. The little machine has many good points. The other lathe is of 5in. centres, and is of more ordinary design, but the saddle is arranged to allow of milling and boring being conveniently mounted on it. The saddle is guided on shears at the level of the bottom of the gap, whilst the back centre stands on shears at a higher level. This arrangement allows the slide rest to be run right up to the head whether the gap is in place or not; in fact, no gap piece is provided. This lathe is arranged to be driven either by overhead gear or by treadle. A flat strap is used.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS,** *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

26,546. December 20th, 1905.—IMPROVEMENTS IN DIRECT-ACTING ENGINES, Robert Richardson, 69, South Cromwell-road, Glasgow.

This invention relates to the auxiliary portion of direct-acting engines, and has for its object to minimise the shock which at present takes place when the main valve is reversed, due to the high velocity imparted to this valve. There are two figures. Fig. 1 is a longitudinal section of a cylinder and valve chamber of an engine fitted with this valve. The piston *a* and the distance piece *c* of the ordinary piston valve are made in one solid casting, and the second piston *b* is secured on to the distance piece and the two pistons are accurately fitted within the cylindrical valve chamber *h*. The piston valve is provided with extensions *d e* at either end, and on these extensions are slidably fitted larger pistons *f* and f^1, which are provided with sleeves *g* g^1. The valve chamber *h* is bored out at each end to an enlarged diameter, and so as to form cylinders. In these cylinders are slidably fitted the larger pistons *f* f^1, and at the inner ends are fitted ring pieces or blocks *i* i^1. The pistons *a b* and distance piece *c* of the piston valve and its extensions *d e* are bored out to receive a spindle valve *j*, which has slight end play, and is reduced at *k* and *l* to form ports, and has longitudinal grooves *m n* extending from these ports in either end of the spindle. Small ports *o* o^1 are made in the distance piece *c* of the piston valve, and cushion springs *p* are provided between the pistons *a b* and the sleeve g^1 *g* of the large pistons f^1 *f*. The piston-rod *t* of the main cylinder is bored a certain distance down its length, and a connecting-rod *u* provided with an enlarged end *v* is fitted in it. The other end of the connecting-rod *u* is pin-jointed

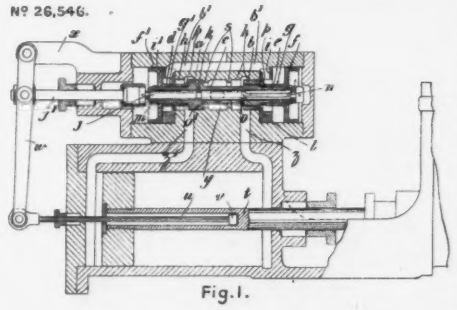


Fig. 1.

to a lever *w*, which is fulcrumed in a bracket *x* on the valve casing. The outer end of the valve spindle j^1 is also pin-jointed to the lever *w*, and its inner end is coupled to the spindle valve so that the latter may have a certain amount of movement independent of the positive movement which is imparted to it by the lever from the connecting-rod. Presuming that the main piston is travelling to the left, steam enters in the usual manner to a central cavity *y* and passes by the inner face of the piston valve *b* and port *z* to the right-hand end of the cylinder, and the exhaust steam from the left-hand end of the cylinder passes by the port z^1, and the outer face of the piston valve *a* into the exhaust port b^1. Just before the main piston reaches the end of its stroke, a slight positive movement is given to the spindle valve *j* by the piston-rod *t* through the connecting-rod *u*, lever *w*, and valve spindle j^1. This movement allows the spindle valve to open the port *o* in the piston valve distance piece *c*, and steam passes from the central cavity *y* through the ports *o* and *l* and the groove *n* to the back of the piston *f*, and at the same time steam is cut off from the back of the piston f^1 by the spindle valve closing the port o^1. The steam at the back of the piston *f* forces the whole, pistons *f* f^1, piston valves *a b*, and spindle valve *j* over to the left, and opens the port z^1 and admits steam from the central cavity by the inside face of the piston *a* to the left-hand end of the cylinder, and exhausts steam from the right-hand end by the port *z* past the outside face of the piston *b* into the exhaust port b^1. The steam which remained at the back of piston f^1 has no outlet to the exhaust, and as the piston moves to the left the steam is compressed and leaks past the edge of the piston into the exhaust port, thus ensuring a steady and gentle travel of the valve. When the valve reaches the end of its stroke, steam-tight joints are made by the piston *f* with the outside face of the ring piece *i*, the piston *b* with the outside face of the projection *s*, and the piston *a* with the inside face of the ring piece i^1.—*October* 31*st*, 1906.

INTERNAL COMBUSTION ENGINES.

21,813. October 26th, 1905.—IMPROVEMENTS IN CARBURETTERS FOR INTERNAL COMBUSTION MOTORS.—*Edward C. Newcomb, 125, West Ninetieth-street, New York, U.S.A.—Date under International Convention, 10th April,* 1905.

This invention relates to carburetters for internal combustion motors, and has for its object to provide a carburetter whereby an internal combustion motor may be operated through a wide range of speeds, and which will give a maximum of effort and efficiency throughout its entire range of speeds, and also to provide means whereby a predetermined relation may be accurately maintained between the supplies of fuel and air to the combustion chamber of the motor and the relation between the supplies of fuel and air may be easily varied. There are four figures. Fig. 1 is a vertical central section of a carburetter. A casing 44 is provided with a horizontal partition wall 45, between which and a lower casing 46 is formed an air-receiving chamber, in which the air and fuel are to be mixed. The air-controlling passage through which air is admitted to this chamber is formed between the upper edge of the casing 46 and the under surface of the partition 45. While the predetermined relation between the supplies of air and fuel may be varied by adjusting the effective area of either or both of the supply-controlling passages, the air-controlling passage is made adjustable by threading the casing 46 in the lower end of the casing 44. The air is supplied through a series of openings in the outer wall of the casing 44, of such number and size as to practically maintain at all times the full pressure of the atmosphere at the outer side of the air-controlling passage. Above the partition wall 45 is a flexible diaphragm 48 clamped between the upper edge of the casing 44 and a cover 49. The space below the diaphragm 48 is placed in communication with the atmosphere by openings 50 in the outer wall of the casing 44, and communication is provided between the air-receiving chamber in the casing 46 and the space above the diaphragm 48 by a tube 51 passing through and loosely fitting a central opening in the partition 45. The supply of liquid fuel enters through a valve 52 opened by an upward movement of the diaphragm 48. A valve-operating finger 53 is carried by the diaphragm. The tube 51 is provided with a fuel-controlling passage 54. A plate 55 and one or more screens 56 facilitate the mixing of the fuel and air and the evaporation of the fuel by the air flowing through the device. Communicating passages 57 may be provided in the partition 45, the area bearing

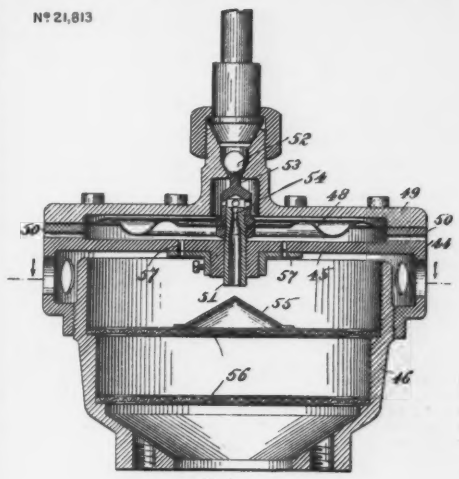


Fig. 1.

such relation to the area of the passage 50 as will cause a slight reduction from atmospheric pressure below the diaphragm 48, the reduction increasing as the reduction of pressure in the air-receiving chamber increases and in substantially the same degree. The result will be that the reduction below atmospheric pressure in the space above the diaphragm 48 will decrease in substantially the same degree, and the ratio between the supplies of fuel and air will be correspondingly changed. In order that this change may be varied and predetermined, means may be provided for regulating the size of either the passages 50 or the passages 57.—*October* 31*st*, 1906.

TURBINES.

22,127. October 30th, 1905.—IMPROVEMENTS IN AND RELATING TO TURBINES, ROTARY COMPRESSORS AND THE LIKE, The Hon. Charles A. Parsons, C.B., and George G. Stoney, both of Heaton Works, Newcastle-on-Tyne.

This invention relates to improvements in portions of air, gas, or steam turbines and compressors, which act more or less as packings, and especially to the fluid packings of blades. In order to reduce the clearance necessary in turbines, and to reduce the chances of damage by contact due to distortion, strips with their edges projecting towards the opposing member have been secured to the blades, these edges being adapted to wear when contact takes place. The invention consists in forming the ends of the blades with narrow edges, or in providing on the blades or the casing or drum strips of serrated cross-section, so that if too close contact takes place between a fixed and a moving part, very narrow edges only are subjected to the wearing action, whereby the tendency to

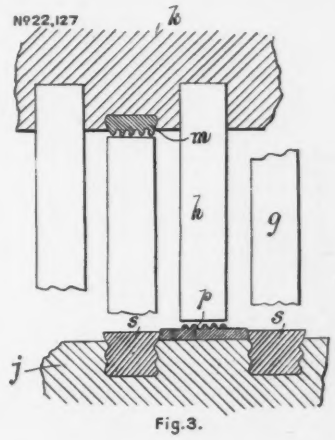


Fig. 3.

damage or stripping, and the losses due to skin friction, are reduced. There are four figures. Fig. 3 is a detail sectional view of a turbine spindle and casing in which a serrated strip of brass or the like is let into the casing and drum opposite the blade tips for reducing wear and skin friction. The moving blades *g* are secured in the turbine spindle *j* in any well-known manner, as by inserting them in grooves in the carrier, and then caulking in a distance piece *s* between each blade and the next. The fixed blades *h* are similarly secured to the casing *k*. Opposite the blades *g* are provided serrated strips *m* of brass or the like fixed in the casing, while opposite the blades *h* a serrated strip *p* is fixed on the turbine drum or spindle. The strip *p* may be of the same form as the strip *m* in the casing, or it may be made wider and be held in position by caulking the distance piece *s* over it. When these strips are worn out, they may be readily replaced.—*October* 31*st*, 1906.

26,643. December 21st, 1905. — IMPROVEMENTS IN TURBINES, William B. Johnson, 4, Clayton-street, Liverpool.

There are two figures. Fig. 1 is a longitudinal section of part of a steam turbine. Alternate and intermediate loose rings 2 3 and 4 5 are employed, to which are affixed the usual curved vanes, buckets, or nozzles 6, which have their concavities alternately in opposite directions; 7 is the rotating part or drum of the turbine, upon which are concentrically arranged the loose rings 3 5; 8 is the usual casing of the turbine; 9 are shafts for carrying the drum 7, and rotating in bearings 10 of any usual kind, suitable packing being used to keep the joints tight; 11 are ordinary packing collars between the drum and casing 8; 12 13 are movable cams or wedges on the casing, and 14 15 are rings or projections fixed to the drum 7, and having wedge faces, teeth, or the like, with which corresponding faces, teeth, &c., on the rings 3 5 can engage when such rings are moved against the rings 14 15. The cams 12 13 are mounted on slides 16 movable in opposite directions in slots

17 in the casing by means of cranked spindles or excentrics 18, which are operated by cranks 19 and rods 20, so that such cams 12 13 engage with the rings 2 and secure them to the casing, and at the same time move them laterally in the direction of the arrow, so far that the rings 3 are clear of the projections 15 14 on the drum, while the rings 4 5 are allowed to move by the pressure of the steam in the opposite direction to the arrow, so that the rings 5 engage with the projections 14, and thus rotate with the drum

Nº 26,643.

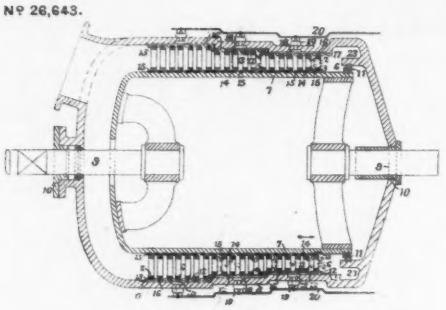


Fig. 1.

on steam being admitted through the inlet 23. To reverse the motion of the drum, the slides 16 and cams 12 13 are moved in the reverse direction, so that the rings 2 are freed, the rings 3 being allowed to move and engage with the projections 15, while the rings 4 are gripped by the cams 13 12, and are moved in the direction of the arrow, so as to clear their corresponding rings 5 from the projections 14. The rings 2 3 are thus secured to the drum, and free of the casing, while the rings 4 5 are secured to the casing and free of the drum. The drum will thus revolve in the opposite direction.—*October* 31*st*, 1906.

LOCOMOTIVES.

25,562. December 8th, 1905.—Improvements in Locomotive Engines, *William Werry, Philip-street, Long Gulley, Bendigo, Victoria, Australia.*

This invention consists in the improved construction and arrangement of the working parts of a locomotive engine to adapt it for high speeds and ease of working under such conditions. There are three figures. Fig. 1 is a side elevation. The construction embodies with the known feature of placing the cylinders above the boiler and the latter below the driving wheel axle, the arrangement and construction of the driving gear, whereby the cylinders are enabled in an improved manner to drive direct on to two driving axles between which they are placed, 1 being the boiler, 1ª the fire-box, 2 the driving wheels, and 3 the cylinders. The latter are preferably three in number, each being provided with two pistons and rods 5, of which may, as shown, carry slotted crossheads 6 horizontally reciprocating in guides 6ª mounted on the boiler 1 or otherwise conveniently supported, in which crossheads reciprocate in a manner well known, slipper blocks or brasses 7 carrying the crank pins 8 of the cranks 9 mounted on the driving

Nº 25,562.

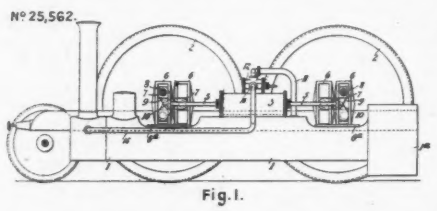


Fig. 1.

axles 10 of the wheels 2, thus directly transforming the reciprocating motion of the piston into the circular motion necessary to drive the axles 10. The strokes of the pistons of each cylinder take place in opposite directions, and are approximately one half the length of the cylinder, the cranks 9 being so set that the pistons are simultaneously at the ends of their strokes. Steam from the boiler 1, or other fluid pressure, is conveyed through a pipe 11 to a piston valve 12, and is admitted to the cylinder 3 about the centre thereof through the inlet port and exhaust at 16, so that the forces due to the motion of the one piston in one direction are balanced by the like forces of the other piston moving in the opposite direction. The driving axles 10 are preferably coupled together with coupling rods, by which means the power expended on the two axles is equalised, any excess of power on the one being thereby transmitted to the other. By this arrangement of parts, a more perfectly balanced engine will be obtained, with a consequently increased freedom from jarring, vibration and the see-sawing action prevalent in locomotives as ordinarily constructed.—*October* 31*st*, 1906.

N.B.—This is included, not with the idea that this design is completely practicable as shown, but as an interesting attempt to lower the centre of gravity.

ELECTRICAL APPARATUS.

21,565. October 23rd, 1905. — Improvements in Selective Signalling Apparatus Applicable for Telephonic and other Purposes, Joseph D. F. Andrews, 2, Park-avenue, East Sheen, S.W.

This invention relates to improvements in that class of selective signalling apparatus in which pendulums or vibrators are employed for selecting purposes, and it consists essentially in a system of transmitting signals by pendulums or vibrators having adjustable bobs, such pendulums or vibrators being so devised in conjunction with magnets that the one pendulum and magnet or set of pendulums and magnets at each station answers for both receiving and transmitting. In the simplest form of the device one pendulum or reed is employed provided with a bob which can be moved along the length of the pendulum or reed so as to alter its rate of beat. A scale is provided close to or on the pendulum to indicate the correct position to place the bob to obtain the required beat. Assume a system of ten stations, the pendulum at each station would be scaled with ten divisions marked Nos. 1 to 10. Each station would have one of the numbers for its own, at which the bob would be kept placed so as to distinguish it from the others. All the pendulums would synchronise when the bobs are at the same number on each scale. Consequently, if No. 1 station wishes to call up No. 5, he could move his bob to No. 5 and then set his pendulum swinging. At each beat the circuit will be momentarily broken or completed by a contact drive, or an induced current created and transmitted. Consequently, an inter-current will pass along the line, corresponding to No. 5 on the pendulum scale, and only the pendulum of No. 5 station will respond and ring its bell by closing the circuit of a magnet provided with an armature, which would be attracted at each impulse and strike a bell, such armature being preferably weighted so that its natural beats would synchronise with the beat of the pendulum when its bob is at the home point. There are three figures. Fig. 1 is a diagram. A is a pendulum of the inverted type, of which B is the bob adjustable to any position. The pendulum oscillates about the fulcrum C, and is weighted below by the armature D, which is presented to the magnet E. If a current be now made to pass by depressing the key V on to the battery contact and simultaneously starting the pendulum A with the finger, the spring G will make and break contact with the spring H at each beat of the pendulum, and send intermittent currents through the magnet E to line and return, and the intermittent currents through the magnet will keep up the oscillations of the pendulum. The impulses of current thus created would pass through the lines and any similar instruments in circuit, and if any of the pendulums of the similar instruments corresponded

Nº 21,565.

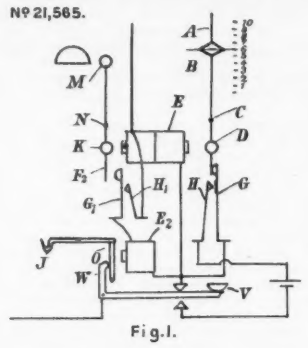


Fig. 1.

in synchronism to the impulses of current they would oscillate and indicate that communication is desired to be made, and in addition ring the bell by the magnet E, attracting the armature K, which is provided at N, and causing the hammer M to strike the bell, this hammer being adjusted to respond to the intermittent currents designed to affect this instrument. A lever O is provided at each station, which interlocks with the telephone hook to prevent the speaking circuit being used unless the instrument is called or calling. To effect this, a magnet E_2 is arranged to attract the lever O away from the hook J, when the armature K has reached its full amplitude, and by means of a projection F_2, depresses spring G_1 on to H_1, and thus energises the magnet E_2, which withdraws the lever O at each impulse. When a current and call is to be transmitted, the key V withdraws the lever O by a projection W impinging on it.—*October* 31*st*, 1906.

MISCELLANEOUS.

14,972A. July 20th, 1905.—Improvements in and relating to the Manufacture of Incandescent Electric Lamp Filaments from Thorium, *The General Electric Company, of Schenectady, Schenectady, State of New York, U.S.A.*

This invention relates to the manufacture of electric incandescent lamp filaments from thorium, and has for its object to provide an improved method whereby the metal may be rendered into a coherent form suitable for use as a filament for an incandescent lamp. The invention consists in a method of agglomerating the metal by incorporating with it magnesium, and in heating the compound so as to drive off the magnesium and leave a coherent or malleable or ductile mass of the metal. The thorium in the state of powder, as it is usually obtained, is mixed with 20 to 100 per cent. of its weight of clean magnesia filings. This mixture is compressed into a lump and heated in a magnesia crucible in the vacuum furnace until all the magnesium has vaporised. After this operation there remains behind a somewhat porous sintered mass, which, after treatment with nitric acid, washing and drying, can be compressed into a dense metallic state, somewhat resembling copper in malleability, and in proper condition to be rolled and drawn into wire. It is believed that by this process, during the heating, an alloy of thorium and magnesium is temporarily formed either before or during the vaporisation of the magnesium, and that this causes the grains or crystals of thorium to be cemented together. Whatever may be the principle that underlies this step of the improved process, it is found that by the operation described a lamp filament can be formed from thorium powder without actual fusion of the powder, and a filament of pure metal of good mechanical strength and high lighting efficiency can be obtained. —*October* 31*st* 1906.

21,549. October 23rd, 1905.—An Improved Process for the Extraction of Gold, Silver, and other Metals from Metal-bearing Matter, *James G. Slater*, 119, *Tyndall-avenue, Toronto, Canada.*

This invention relates to an improved process in the extraction of gold and silver from metal-bearing matter, such as ores, sand, quartz, alluvial earth or tailings from quartz, placer mining and dredging, and the object of the invention is to provide a process which will extract not only gold and silver, but the residue of the other metals after the gold and silver have been extracted. The process consists shortly, first, in reducing the metal-bearing matter to an impalpable powder, and then in treating such powder by the usual mercury and cyanide process and final process. The impalpable powder is subjected to the usual mercury process to recover as much gold and silver as possible. Then the residue is treated with any usual form of cyanide process to recover any gold and silver not recovered by the mercury. To the residue is added, to each one pound Troy of the same, one pound of nitrate of potash or thereabouts, and one-half pound of sea salt or thereabouts. After adding the above chemicals to the residue all is ground together. Two ounces of copper or thereabouts are added to one pound of the mixture, care being taken to place the copper at the bottom of the crucible or retort. The mixture is then placed in a furnace without disturbing the copper. The furnace is provided with a close lining having a vent, which is connected to what is termed an accumulator, which is a settling or condensing device designed to recover the sulphides coming off in the form of gas. This accumulator is a receptacle which is connected to the top of the furnace by a suitable pipe through which the sulphide gases from the molten metal pass. A hard coke fire is employed at a temperature of 2000 deg Cent. or thereabouts. After boiling for one hour the button is removed; that is to say, the copper and metals adhering thereto, which form an alloy of the copper and other metals, and which are located in the bottom of the crucible. The action of the nitrate of potash and sea salt is to form a flux, the copper attracting the various metals contained in the flux and forming the button. After the button has been removed, it is treated by the various processes known in the art, so as to separate the various metals.—*October* 31*st*, 1906.

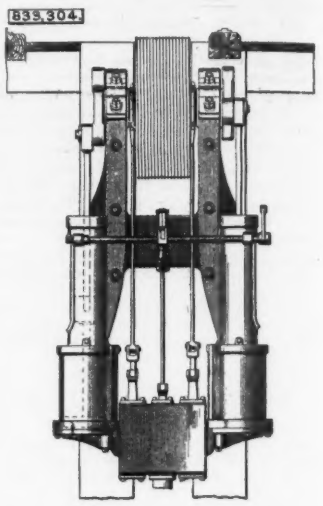
SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

833,304. Engine, *C. E. Cleveland, Fond du Lac, Wis.—Filed September 29th*, 1904.

This invention refers to the castings of which an engine is composed. The claims, of which there are three, are for a twin engine frame composed of three main members, the first and second each

833,304.



comprising a cylinder, shaft bearing, and portion of a cross brace, and the third comprising a valve chest and two cylinder heads.

833,467. Apparatus for Purifying and Reheating Furnace Gases, *D. Lamond, Pittsburg, and D. D. Lamond, Allegheny, Pa.—Filed April 9th*, 1904.

This invention consists in the use of settling chambers for the

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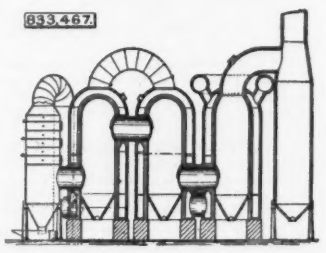
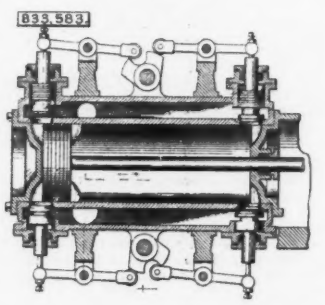


deposit of dust, surrounded by hollow walls. The space between is utilised by passing the purified gas through it. The gas is thus heated because the impure gas is at a high temperature. There are seven claims covering details.

833,583. Valve Gear for Steam Engines, *C. W. Crawford, Brazil, Ind.—Filed July 17th*, 1905.

The cylinder is provided with admission and exhaust poppet

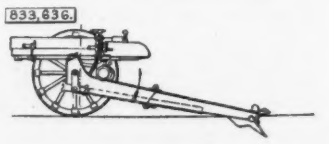
833,583.



valves at each end, which are opened by the pressure of the steam and closed and kept closed by oscillating cams, as shown. There are eight long claims.

833,636.—Trail for the Carriages of Guns Mounted on Wheels, *C. P. E. Schneider, Le Creusot, France.—Filed January 3rd*, 1906.

833,636.

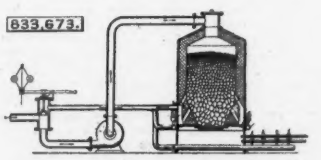


The invention consists in the use of a trail, which can be locked to the axle at various angles. There are three claims for details.

833,673.—Means for Maintaining Heat in Gas Producers, *E. Capitaine, Frankfort-on-the-Main, Germany.—Filed March 27th*, 1905.

This invention consists in the combination with a gas producer of a suction gas-outlet pipe therefrom, and a gas-delivery pipe for supplying gas to a gas engine, of a gas exhauster arranged between

833,673.



said pipes, a gas-outlet valve in the delivery pipe, a governor adapted to automatically open this gas valve to a greater or less extent when the load on the engine falls below a predetermined amount, and means for conducting away and burning the escaping gas so as to heat the gas producer. There are six claims.

MACHINE TOOL DESIGN.

By Professor J. T. NICOLSON, D.Sc., M. Inst. C.E., and Mr. DEMPSTER SMITH.

NO. XXVI *

WHAT we now propose to do is to fix the proportions of journals by reference to the minimum points of the experimental friction curves already discussed, assuming them to indicate the critical conditions as regards speed, pressure, and temperature of the bearing, below which it is unsafe to run.

We first calculate the terminal rise of temperature of the bearing by the expression $\theta_f = (d\,N)^{3.4}/4$. We then equate this to the value $\theta_c = 80\ v/p$ of the above critical temperature; and so obtain a relation between the length, the load, the diameter, and the speed of revolution.

We thus have:—

$$\frac{(d\,N)^{\frac{3}{2}}}{4} = \frac{80\ v}{p}$$

Substituting $\pi\,d\,N/12$ for v, and P/ld for p, we may write this:—

$$\frac{(d\,N)^{\frac{3}{2}}}{4} = \frac{80\,\pi\,d^2\,N\,l}{12\,P}$$

From which we obtain:—

$$l = \frac{P}{52\,d^{2.4}N^4} \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

In applying this method to the design of the front bearing of a lathe spindle, it may be remarked that, in the formula $\theta_f = \frac{(d\,N)^{\frac{3}{2}}}{4}$, the constant was determined by the consideration of the final temperatures assumed by Stribeck Sellers' bearing; and that the coefficient of emissivity—upon which that constant depends—will certainly be greater for the massively proportioned plummer blocks of a headstock, and the corresponding value of θ_f will be less.

We shall for the present neglect this and adhere to the above formula, the result being that we shall err on the safe side. The diameter of the spindle is fixed by considerations of strength, and its value as a function of the height of centres has been fully discussed above. For our present purpose we may take it as: $d = h/3$. The spindle speed for which the bearing must run cool is clearly the highest for which the lathe is designed; and for this we have given the rule $N\,g = 3600/h$.

Thus we find that the product $d\,N$ *is a constant for all sizes of lathe.* In fact $d\,N = 1200$, and $(d\,N)^{\frac{3}{2}} = 205$.

Hence $\theta = \frac{1200^2}{4} = \frac{205}{4} = 51°$ Fah.

So that $(51° + 60°) = 111°$ Fah. is the terminal temperature which all front bearings should assume, no matter what may be the size of the lathe, if the above experimentally determined coefficients are correct.

If this calculated temperature ($\theta = 51°$) is higher than that at which the oil begins to squeeze out under the given conditions of speed and pressure, the bearing will run dry and seize.

Therefore $\frac{(d\,N)^{\frac{3}{2}}}{4}$ must be not greater than, or at most equal to, $80\ v/p$.

That is $$\frac{80\,\pi\,d^2\,N\,l}{12\,P} = 20\frac{d^2\,N\,l}{P} = 51$$

$$\text{or } l = \frac{51}{20}\frac{P}{d^2\,N} = 2{\cdot}5\,\frac{P}{d^2\,N} \quad . \quad . \quad . \quad (22)$$

Taking $P = 80h^2$ (twice the cutting force due to the standard cut $a = h^2/6400$)

„ $d = h/3$

and $N = 3600/h$, we have:

$$l = 2{\cdot}5\,\frac{80\,h^2 \times 9 \times h}{h^2 \times 3600} = h/2. \quad . \quad . \quad (23)$$

The length of the front bearing should be equal to half the height of centres.

This line has been plotted on Fig. 89, page 466, and agrees very well with the spots from practice for high speed steel lathes.

In the authors' opinion this requirement is, however, in excess of what is actually necessary. Lathes are hardly ever run for so long as to allow the journals to attain their maximum temperatures. Experiments have shown that an ordinary Sellers' bearing requires to be run more than three hours to reach its highest temperature; and when we have regard to the relatively greater massiveness of the proportions of shafts, housing, and caps, in a lathe headstock, it will readily appear that a much longer time will be required before the final temperature is reached; that, in short, it will hardly ever be attained—except in special lathes. If, then, we determine the temperature reached by a lathe spindle bearing as a function of the mass of shaft and housing which receives the heat, and of the greatest ordinary length of run, and design the bearing so that this temperature shall always be lower than that at which the oil film begins to get too thin, we should find that a smaller length of journal than that above specified will be sufficient.

Let the mean (excess) of the temperature of the bearing over that of the air be θ at t minutes from the start, and in a little time $d\,t$ let that temperature rise $d\,\theta$ degrees. Neglecting emissivity, for a first approximation, the heat generated and received by the bearing in time $d\,t$ is

$$\frac{\mu\,P\,\pi\,d\,N}{12\,J}\,d\,t = \frac{c\,\sqrt{\pi\,d\,N}}{\sqrt{12\,\theta\,p}}\,\frac{P\,\pi\,d\,N}{12\,J}\,d\,t$$

$$= \frac{c\,(\pi\,d\,N)^{\frac{3}{2}}\,l\,d}{12^{\frac{3}{2}}\,J\,\theta}\,d\,t$$

The weight of that part of shaft and housing which takes this mean temperature is proportional to $l\,d^3$, so that if S be its capacity for heat per unit volume, the heat absorbed per degree rise of temperature will be $C\,s\,l\,d^3$. We have therefore:

$$\frac{c\,(\pi\,d\,N)^{\frac{3}{2}}}{12^{\frac{3}{2}}\,J\,\theta}\,l\,d\,t = C\,s\,l\,d^3\,d\,\theta.$$

Putting as before $c = 1{\cdot}8$; taking the thermal capacity per cubic inch of shaft and bearing material to be 0·04 T.U. and assuming the volume of metal that takes up the heat generated to be $9\,l\,d^3$, we have:

$$\frac{1{\cdot}8\,\pi^{\frac{3}{2}}}{778 \times 12^{\frac{3}{2}}}\,\frac{(d\,N)^{\frac{3}{2}}}{\theta}\,d\,t = 0{\cdot}36\,d{\cdot}d\,\theta,$$

$$\text{or } 1240\,\theta\,d\,\theta = d^{\frac{1}{2}}\,N^{\frac{3}{2}}\,d\,t.$$

Putting $d = h/3$ and $N = 3600/h$; this reduces to $\theta\,d\,\theta = \frac{101}{h}\,d\,t$; from which, by integration,

$$\theta^2 = \frac{202}{h}\,t \text{ or } \theta_t = \frac{14}{\sqrt{h}}\,\sqrt{t} \quad . \quad . \quad . \quad . \quad (24)$$

Here θ_t is the temperature the bearing will have attained (above that of the outside air, taken at 60 deg. Fah.) after running for t minutes, the lathe being of h inches height of centres.

If it may be taken that the longest continuous run is the same for all sizes of lathe, say, three hours, or 180 minutes; then

$$\theta_{180} = \frac{14\sqrt{180}}{\sqrt{h}} = \frac{188}{\sqrt{h}} \quad . \quad . \quad . \quad . \quad (25)$$

Thus for h = ...	9in.	25in.	49in.	100in.
$\sqrt{h}$ = ...	3in.	5in.	7in.	10in.
$\theta_{180\ min} = \frac{188}{\sqrt{h}}$ =	63in.	38in.	24in.	19in.
$\theta + 60$ = ...	123dg.	98 deg. Fah.	84 deg. Fah.	79 deg. Fah.

The time assumed, three hours, is probably long enough for the terminal temperature to have been obtained in the case of the 9in. lathe. That it should be greater than the previously calculated value 111 deg. Fah. by the formula $\theta_f = (d\ N)^{3.4}/4$ is only what we should expect, seeing that external radiation has been neglected in the present case. We observe that the rise of temperature of the bearing for a given length of run is inversely proportional to the square root of the size of the lathe; whilst, for any given lathe, it is directly proportional to the square root of the length of the run.

To secure that the temperature (θ_t) shall not be high enough to cause the oil film to be squeezed out, we must have—

$$\theta_t \leq \theta_c;\ i.e.,\ 14\sqrt{\frac{t}{h}} < \frac{80\ \sqrt{v}}{p} \text{ or } 14\,\sqrt{\frac{t}{h}} = \frac{80\,\pi\,d^2\,N\,l}{12\,P}$$

$$= 20\,\frac{d^2\,N\,l}{P}.$$

$$\text{That is } l \geq 14\,\sqrt{\frac{t}{h}}\,\frac{P}{20\,d^2\,N} \quad . \quad . \quad . \quad . \quad . \quad (26)$$

If, for example, we take $t = 180$ minutes (3 hours) then since $P = 80\ h^2$, $d^2 = h^2/9$ and $N = 3600/h$; we get:

$$l = \frac{188}{\sqrt{h}}\,\frac{80\ h^2 \times 9\ h}{20 \times h^2 \times 3600} = \frac{188}{\sqrt{h}} \cdot \frac{h}{100'}$$

$$\text{or } l = 1{\cdot}88\ \sqrt{h} = \text{say, } 2\,\sqrt{h}. \quad . \quad . \quad . \quad (27)$$

If we then take the formula $l = 2\ \sqrt{h}$ for the length of the front bearing in terms of the height of centres, we obtain the following figures:—

h =	in. 6	in. 9	in. 16	in. 25	in. 36	in. 49	in. 64	in. 81
$l = 2\sqrt{h}$ =	4·9	6	8	10	12	14	16	18
But for $l = h/2$ =	3	4½	8	12½	18	24	32	40

These two values have been plotted as ordinates on a base of heights of centres in Fig. 89; and may be compared with the results plotted—as hollow black dots—from practice. It would appear that for lathes larger than 12in. centres the front journal has, in general, been made longer than the above theory requires.

Case II.—We have next to consider the second of the extreme conditions under which a lathe spindle has to run, as specified above; that, viz., of carrying a heavy load, or sustaining a heavy cut at a very slow speed.

What we have now to guard against is the entire collapse or tearing asunder of the film of lubricant, owing to the slow speed at which the bearing is being worked. Stribeck's—and Heimann's—curves of speed and pressure—at constant temperature—show that, after the minimum points are passed, as the speed still further diminishes the coefficient of friction begins to rise very rapidly, and that, whatever the load may be, all the curves converge upon the value 0·15, the coefficient of "dry" friction for greasy metals, determined by Morin. The rate of rise of the friction curve depends on the amount of bearing pressure; being much more rapid—at all events for a Sellers bearing, *v.* Fig. 96—for low than for high bearing pressures. A low pressure is accompanied by a low speed for the "minimum point," and when once the tearing of the oil film begins the journal is unable to bring up a fresh supply, owing to its small surface speed. High bearing pressures have their minimum friction points at high speeds, and the journal brings up considerable quantities of oil, even when the speed has become low enough to break the film, so that the resulting friction is probably partly due to viscous resistance, and partly to metallic contact.

The values of the speeds for the minimum points of the coefficient of friction curves—Figs. 96 and 97—as they depend on the bearing pressures which we used before, will now again serve as indicating the dangerous conditions to be avoided if the oil film is to remain unbroken.

The Sellers bearing gave the relation $v_o = \frac{1}{2}\,p$, and the bush bearing $v_o = \frac{1}{16}\,p$, for these points. If, therefore, the surface speed of the journal be v feet per minute, the bearing pressure may not exceed $2\ v$ lbs./sq. in. for a bearing in halves, and $16\ v$ for a solid or bush bearing, if metal-to-metal contact of journal and bearing is to be avoided.

Applying this principle to the actual case, we must find what surface speeds are met with in practice, and what bearing pressures we encounter when the lathe is running at its slowest velocity of rotation and taking its deepest cut or carrying its heaviest load.

It may fairly be assumed that every lathe will at times be called upon to take a finishing cut at a speed of 18ft. per minute upon a heavy job of face plate diameter, of the greatest length the lathe can take in; and of which one-third the weight will be taken by the front journal. We obtain therefore the following value of load and speed:—

The weight of the job assumed $2\ h$ in diameter and $6\ h$ long is

$$\frac{\pi}{4}\,(2\,h)^2 \times 6\,h \times {\cdot}3 \text{ lb.} = 5{\cdot}66\ h^3 \text{ lb.}$$

One-third of this will be $2\,h^3$ (and allowing for the weight of face-plate, &c.); or $W = 2\ h^3$

If the bearing be taken of diameter $\frac{h}{3}$, the rubbing speed is $18 \times h/3 \times 2\ h = 3$ft. per minute, and according to the above table the safe load is therefore from 6 lb. to 48 lb. per sq. in. of projected bearing area. But the actual bearing pressure will be (if we assume the usual value $h/2$ for the length of the journal):—

$$p = \frac{2\ h^3}{\frac{h}{2} \times \frac{h}{3}} = \frac{12\ h^3}{h^2} = 12\ h;\ i.e.,\ 120 \text{ lb./sq. in.}$$

for a 10in., and 600 lb./sq. in., for a 50in. lathe.

We see, therefore, that it is impossible to give the large dimensions to the front bearing that would be necessary to prevent the oil film from being broken at such slow speeds, and *as a matter of fact, lathe spindles turning at the slow speeds used for heavy cuts inevitably run metal-to-metal with their brasses, giving rise to the high frictional resistance corresponding to the coefficient of friction of* 0·15 *for greasy metals.*

The work thus spent and wasted on friction and wear may, as worked out above, amount from to 2 per cent. to 11 per cent. of the total useful work expended on cutting at the standard rate (area $= h^2/6400$). From ¼ to 9, according to size, horse-power is, therefore, wasted on the friction *of the front journal alone* when the lathe is running at these slow rates with a heavy job between centres.

Even if the job be light and the thrust on the front journal that due to the standard cut only, we saw above that 2½ per cent. of the useful work is spent on friction on any size of lathe when the speeds are so low as to squeeze out the oil film.

We are here face to face with a very serious loss of power, and a correspondingly large amount of wear of the spindle and brasses in the front bearing, not at all due to high speeds of rotation of the spindle; and it is owing to this that the elaborate arrangements for adjustment of the spindle in a lathe headstock have to be provided.

It is impossible to give enough area in the front bearing of a lathe headstock to prevent metallic contact of journal and brass at the slower speeds, if dependence is placed upon the lubricant being carried in by the ordinary action of the shaft's rotation, the supply being automatic.

By using a force pump, however, and injecting a stream of moderately heavy oil into the bearing *at the place where the pressure is greatest*, it is possible to raise the journal off the brass even when at rest, and to keep it floating with a film of oil interposed between itself and the bearing when in motion, be that motion as slow and the load as high as it may.

If metal-to-metal contact can in this way be prevented at slow, and by the ordinary methods at high speeds, there seems to be a possibility that *wear may be entirely eliminated.*

If this be so, it follows *that adjustments for wear are unnecessary*, and instead of the elaborate and expensive designs of front and back bearings which are now used we may expect that a simple solid bush of ample thickness and of a length not greater than $2\sqrt{h}$, as indicated above, will meet every requirement.

Such a solid bush, of hard bronze round the steel spindle, has a great deal to recommend it from the point of view of accuracy of fit, solidity and stiffness, as compared with the intricate methods of adjustment which are now common.

The length of the back bearing.—The diameter $d_1 = h/4$ and N is, as before, $\frac{3600}{h}$; $\therefore d_1\,N = 900$, and $(d_1\,N)^{\frac{3}{2}} = 165$. Therefore $\theta'_f = \frac{165}{4} = 41$ deg. Fah.

(Or the terminal temperature is 101 deg. Fah.). This must be equated to $80\ v/p$.

$$\therefore\ 41 = \frac{80\,\pi\,d^2\,N\,l}{12\,P} = 20\,\frac{d^2\,N\,l}{P}$$

$$\text{or } l = 2\,\frac{P}{d^2\,N}$$

Taking $P = 40\ h^2$ $d = h/4$, and $N = 3600/h$,

$$= 2\,\frac{40 \times h^3 \times 16}{h^2 \times 3600} = 2 \times {\cdot}18\,h$$

$$= 0{\cdot}36\ h.$$

The length of the back bearing should be ⅓ of the height

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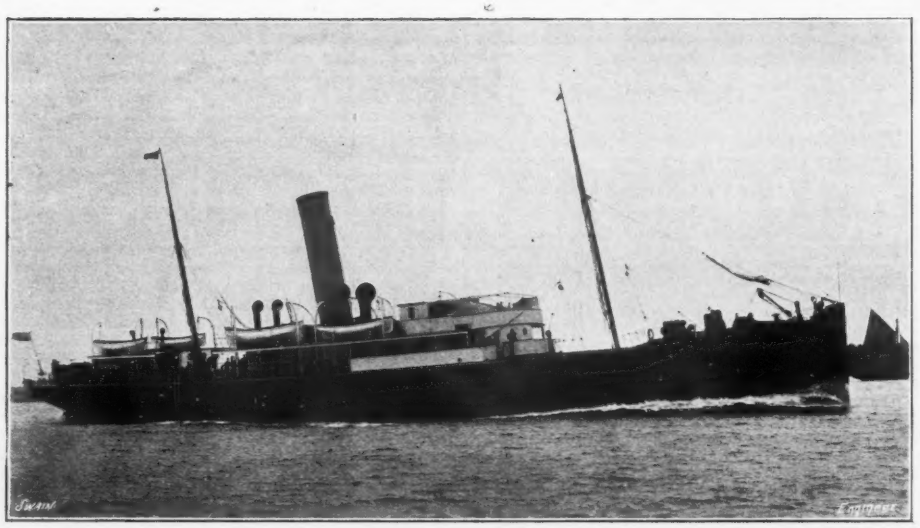
L. & S. W. CHANNEL STEAMER PRINCESS ENA

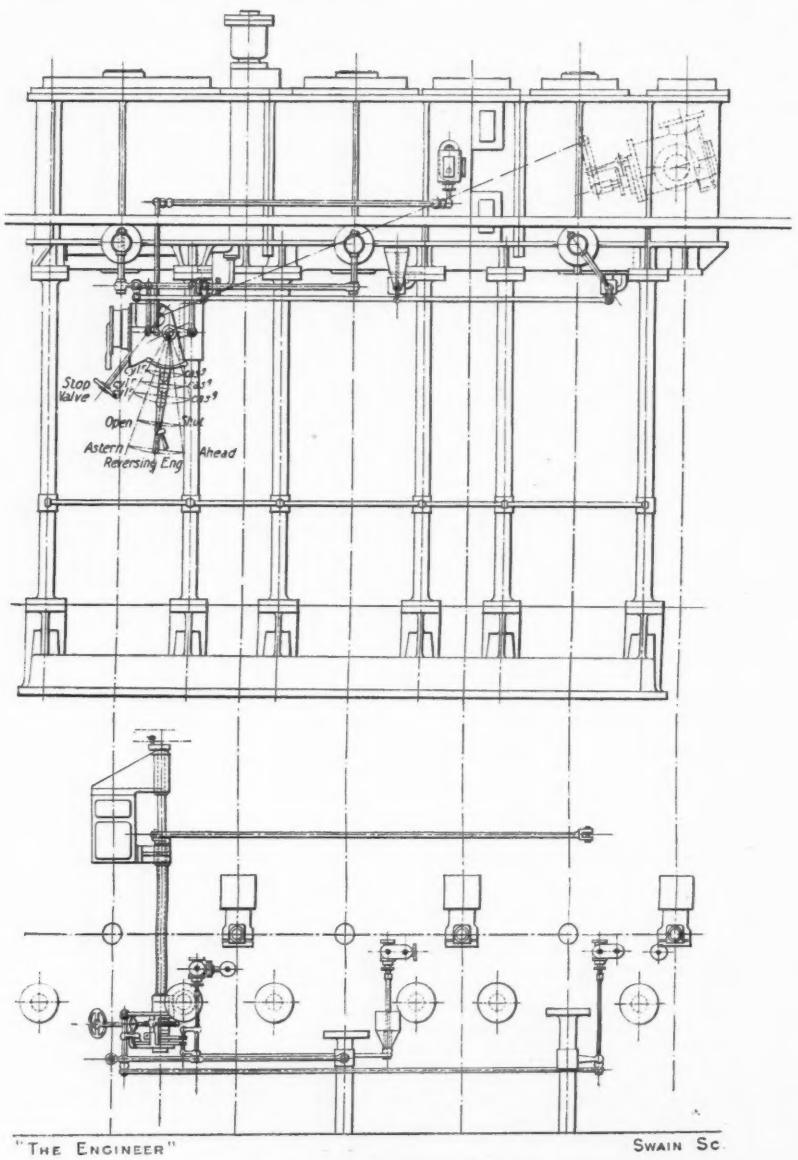
GOURLAY BROS. AND CO. (DUNDEE), LIMITED, DUNDEE, ENGINEERS



of centres. This line has been plotted on Fig. 89, and may be compared with that drawn to fit the spots which has the equation $h/3 + 2$.

THE CHANNEL STEAMSHIP PRINCESS ENA.

THANKS to the courtesy of the directors and Mr. Drummond, chief mechanical engineer of the London and South-Western Railway, we are enabled to illustrate and describe a steamship which possesses features of unusual interest. The Princess Ena is the latest addition to the Channel fleet of the company, the ships of which ply between the Channel Islands, St. Malo, and Southampton. Such well-known steamers as the Vera and Frederica, which have done excellent service for some years, no longer complied with the conditions of comfort which are demanded in the present day, and alive to the fact, Mr. Drummond resolved that the Princess Ena should be up to date in the fullest sense of the words. The result is, in point of fact, a miniature liner. Great care in disposing of the available space has entailed what is, considering the comparatively small size of the boat, wonderful accommodation. Thus there are no fewer than fifty first-class cabins, none with more than two berths, while fifty second-class passengers are very much better off than any first-class passengers were even a few years ago. The general arrangement will be gathered from our Supplement. The joinery work throughout is of the finest class, and reflects no small credit on the workmen of A. H. McIntosh, Limited, of Kirkcaldy, N.B., by whom it was constructed. The main dining saloon is placed amidships, and extends the whole width of the vessel, and is beautifully fitted up in satinwood panels with dark mahogany framing. A very handsome entrance hall leads to the saloon, and off that is a ladies' boudoir, panelled in white with inlaid—not painted—festoons of flowers. The upholstery of this apartment is dark blue.



ENGINES OF THE PRINCESS ENA

A large smoking-room is provided in the forward part of the upper deckhouse. This is fitted with oak panelling and a frieze of red tiles, the whole being an imitation of an old Dutch interior.

Much thought has been given to the comfort of the crew, for whom a special galley has been provided; and on the boat deck, to which passengers have not access, a shelter is placed, to which the men can get direct up a ladder from the stokehold if they wish for air and a smoke, without coming into contact with the passengers. All the fittings of the ship throughout are those of a luxurious yacht; the prevailing colour is white in enamel, and she is brilliantly illuminated by electric lights.

But something more was needed to secure the comfort of the passengers. Most of the other vessels in the fleet have very flat floors, with a rise of not more than 4in. They roll as a consequence, and, when listed, do not readily come up again. This trouble has been quite overcome in the Princess Ena; she has a rise of floor of about 18in., a considerable sheer, and lofty flaring bows, which do much to keep her dry forward in even heavy head seas. Her bulwarks forward are high and carefully stiffened with gussets. The hatches are provided with unusually high coamings, and the gangways instead of being cut down to the waterways as usual, have sills as deep as the hatch coamings, which greatly strengthen and stiffen the ships. Wooden platforms are laid down when taking or discharging cargo, which rest on the coaming at one end and on the sill at the other, so providing a level gangway. The main hatch forward, over 20ft. long, is of such dimensions that the largest motor car made will pass down it. Every possible facility has been supplied for dealing with the peculiar Channel Island traffic. Thus, in the season as many as 30,000 baskets of tomatoes may be put on board in St. Peter's Port, Guernsey, in a couple of hours. At other seasons potatoes take the place of tomatoes, and there is usually much miscellaneous lading to be handled. There are 29,587 cubic feet of cargo space.

Turning, now, to the propelling machinery, we find that Mr. Drummond has made a new departure. Instead of putting in comparatively slow-running, heavy engines, he has fitted the Princess Ena with two triple-expansion engines comparatively small and light, power being got by speed. The engines make 200 revolutions a minute, and forced lubrication is provided for all the main bearings. We give sections and an end elevation of the main engines in our Supplement. The cylinders are 16in., 26in., and 41in. in diameter, with a piston stroke of 24in. The crank shafts are fitted with back balances on the crank webs. They are 7¾in. diameter; the main bearings are 9¾in. long. The crank pins are 7¾in. in diameter by 13¼in. long. The high and intermediate cylinders have piston valves, the low-pressure a relieved slide valve. The Stephenson valve motion has double bar links. The condenser is in three sections, each being a casting in one with an engine back frame. The total length between the tube plates is 16ft., and a special bulkhead door is fitted opposite the after end of each condenser, to allow the tubes to be drawn or replaced. Water is circulated by centrifugal pumps. The air pumps, by Weir, are, with their steam cylinders, self-contained. The general arrangement is clearly shown in our Supplement. The engines drive two bronze propellers, each 9ft. diameter, and 9ft. 6in. pitch, three-bladed; the expanded surface of each is 24 square feet. The shafts rake downwards, being 1ft. 6in. higher at the forward than they are at the after end—an arrangement which tends to prevent broken water in the ship's wake.

Steam is supplied by three Scotch single-ended boilers, with three Deighton furnaces in each, 3ft. 6in. diameter inside the smallest place. The total grate area is 195 square feet, and heating surface 5500. The boilers are each 13ft. diameter, and 11ft. 6in. long, and are worked with natural draught. The engines indicate about 1250 horse-power for each screw, and the speed of the ship is 16·5 knots. The mean draught of the Princess Ena is 14ft. 1in. She has bunker space for 80 tons, and burns on an average 36 tons on the voyage out and home. She has now been running for several months, and has proved herself a most satisfactory vessel. She is a fine, steady, fast sea boat, very easily handled—a matter of immense importance in the Channel Island service—very economical to work, and extremely popular with tourists. All over the ship, indeed, will be found indications of the thought which has been taken for them. Thus we may mention the sheltered seats or alcoves on the shelter deck and the long promenade available from right aft to the break of the upper deck forward. It is not easy, indeed, to realise that we have here a boat only 250ft. long between perpendiculars, 33ft. beam, depth moulded to main deck 15ft. 9in., and to the upper deck 23ft. 3in.

She was built and engined by Gourlay Brothers and Co. (Dundee), Limited, of Dundee, and justly maintains the very high reputation of that firm.

The adoption of high-speed engines in this case by Mr. Drummond and the success attained can hardly fail, we think, to give the reciprocating engine new life, and cause shipowners to think twice before they take up the turbine for the smaller class of steamships.

IT is stated in the *Iron Age* that the general use of compressed air in boiler shops, which has largely aided in advancing boiler shop practice to the front rank in railway mechanical departments, is being extended in some shops to include the cleaning of crown bars and crown sheets with a sand blast. It is claimed that this gives much more satisfactory results than the old method of hammer and chisel. In a certain shop where the new method has been installed a dozen bars took a man ten hours under the discarded system, at a labour cost of 7s. With the sand blast a bar is cleaned in twenty or thirty minutes, or about half the former time, and the job is a cleaner one when done. The same shop uses the blast with satisfactory results for cleaning the crown sheet as well.

THE NEW INCANDESCENT ELECTRIC LAMPS.

No. I.

The great competition which the incandescent electric light has had to face since the introduction of the incandescent gas light has given a strong impulse to the efforts which have been made to improve incandescent electric lighting in technical and economical directions. The principal improvements have been in the direction of the application of substances other than carbon for the manufacture of the light-giving body—as, for instance, in the Nernst, Osmium, and Tantalum lamps—and towards the further development of the existing systems of incandescent lamps using the carbon filament. The latter direction makes for the solution of the question in the application of lamps of high tension, the other in the employment of low voltage lamps. The high voltage lamps, however, have only been made so as to be efficient when high light powers are concerned, and the low voltage lamps have turned out to be uneconomical. The first Edison lamps required 4·5 to 5 watts per candle-power, whilst for the last twenty years lamps have been produced which use 3·5 watts per candle. Many special lamps, devised for high tension, work even with only 2·5 to 3 watts per candle, and have at the same time a good illuminating power and a relatively long life. The power of the carbon electric lamps seemed to have reached its end, for all attempts to impart greater resistance to the carbon filament by the addition of other substances have turned out of no avail. As an infusible body carbon is an ideal substance for incandescent electric lamps, if it had not the unpleasant property of disintegrating during incandescence in a vacuum, whereby the glass walls are blackened, and on this account a considerable amount of light absorbed. But furthermore also the alteration of the structure of the carbon filament, in conjunction with the disintegration, is connected with a greater consumption of current to produce the same light, so that through these two factors the economy of the lamp is in no small way prejudiced. The disintegration is hastened with rise in temperature, so that incandescent carbon lamps for tensions of 200 to 250 volts lose their illuminating power more quickly, and have, accordingly, a much shorter life in practice than low voltage lamps, say up to 110 volts. Consequently, much improvement in the carbon filament lamps cannot be expected. Efficient lighting demands in an economical source of light the highest possible temperature of incandescence, and the efficiency depends upon the law that the amount of light which an illuminating body emits increases with the fifth power of its temperature—that is to say, extraordinarily rapidly. An example will make clear the great importance of this law. An electric incandescent lamp whose carbon filament has a temperature of 2000 deg. absolute, and emits light of 30 normal candle-power, would at double the temperature, 4000 deg. absolute, emit not twice the amount of light, but $2\times2\times2\times2\times2$ times the amount—that is 32 times the amount, or about 1000 candle-power. At the same time, the amount of current used decreases with rise of temperature.

On account of the above principles researches have been directed towards the discovery of other bodies which are better adapted than carbon for light-giving bodies in incandescent lamps. Nernst assumed that among the metallic conducting bodies—the so-called conductors of the first class—no substance existed which was adapted for the production of an economical lamp; he turned, therefore, to the conductors of the second class—the so-called electrolytes, which are decomposed by the electric current. It was ascertained that the oxides of magnesium, zirconium, thorium, yttrium, and other metals of the rare earth series, which do not conduct the electric current at all at ordinary temperatures, soon lose their electrical resistance with rise of temperature, and become decidedly good conductors. It was found also that by a suitable mixture of the earths—zirconium earth and yttrium earth—the decomposing action of the current could be for the most part prevented, but the property of the conductors of the second class—namely, to conduct the current when heated—proved a great and fundamental disadvantage of the Nernst lamp which has hitherto not been overcome. The heating-up arrangement of this lamp is undoubtedly its most wonderful feature, and has been the object of by far the most attempts at improvement. Efforts have not been wanting to overcome the last-named evil by an ingenious combination of the Nernst lamp and the carbon filament lamp, but their great sensibility to variations in current and the inconvenience of their slow lighting militate largely against their general use.

The same inventor to whom gas-lighting owes its rescue has given a new weapon to the supporters of electric lighting. Towards the end of the ninetieth year of the last century Auer von Welsbach was occupied in the production of a better incandescent material for electric lamps, and he discovered that a very suitable metal was osmium, one of the elements in the platinum group. This metal can only be fused in the electric arc. Since osmium, on account of being exceedingly brittle, cannot be drawn in the form of wire, Auer had to find a special process to convert amorphous osmium metal into wire form. From finely powdered osmium metal a paste was prepared by the addition of some organic binding material, from which, by means of a press, very thin threads were produced. These were dried, and finally heated in vacuo until the organic matter was carbonised, and became a conductor of the electric current. The filaments, which contained osmium and carbon in a very fine state of division, were then heated to the highest white heat for a long time in an atmosphere of reducing gases, such as hydrogen saturated with steam. In this operation the carbon was eliminated, and the fine particles of osmium remained behind united in a solid wire.

The great question in connection with the osmium lamp was the difficulty of obtaining osmium in quantities necessary for the manufacture of the lamp. Until quite recently osmium was only produced in small amounts as a by-product in the manufacture of platinum. To produce osmium lamps on a large scale, however, demands much larger quantities. After Auer von Welsbach had bought up all supplies of osmium, he came before the public with his invention. Immediately the price of osmium, which had formerly no practical application whatever, went up to the figure of £250 per kilo. But the Auergesellschaft announces that it is provided with enough osmium for several million lamps, and for current requirements, and no doubt it hopes to recover the greater part of the material going out by sale, since it allows 9d. per lamp for all those returned. A mining company has also been formed under its auspices, which will attend to the further delivery of osmium in sufficient quantities.

Just as the metals in the solid form conduct the electric current, so they do in the liquid and gaseous conditions. The conduction of the current by mercury vapour is one of the oldest methods of producing electric light; an Englishman, Way, as far back as 1860, pointed out the great production of light which this process afforded. After this early investigation the mercury lamp was long forgotten; twenty years later it was heard of again, through the patents of Rapieff and Rizet on the subject. These, however, as well as the patent of Langhaus—1887—found no wider application than for laboratory purposes. The mercury lamp of Arons—1892—marked a real advance, but this also found no general application as a means of illumination. The first investigator so to improve the mercury lamp as to give it practical value was Peter Cooper Hewitt*, who a few years ago conducted careful inquiries into the electrical properties of quicksilver vapour. Hewitt found as the essential condition for the construction of a useful lamp, that in the interior of the lamp a definite temperature and gas density must prevail in order to produce an economical and advantageous light. The principal factor which militates against the general introduction of these lamps is the fact that the colour of the light is bluish green. The red rays are absolutely missing, so that all colours are altered. The mixture of light of the Hewitt lamp is therefore of a different basis from sunlight. In all light phenomena there exist, besides the light-giving visible rays, also dark rays which are not perceptible to the eyes. These dark rays consist of two kinds, the ultra-red or heat rays of long wave-length, and the ultra-violet photographic, chemical, or actinic rays of short wave-length. Whilst the light and heat rays from the action of the sun and all artificial sources of light have been known and used for a long time, the discovery of the ultra-violet rays is due to more recent investigation with highly perfected apparatus.

In the course of the last ten years physicists and physicians have shown that this emission of energy, the ultra-violet rays, is not only of scientific interest, but is connected with valuable properties for the use of mankind. Hence grows the need to make accessible the apparatus and contrivances with which it is possible to produce this class of rays in addition to the heat and light rays in a convenient and economical manner. For this purpose the Hewitt lamp served as an excellent foundation. Since ordinary glass does to allow the ultra violet rays to pass through, but absorbs them, it was therefore necessary to choose some other material, and fused rock-crystal was found to satisfy this requirement. Then the firm, W. C. Heraeus, of Hanau, manufactured mercury lamps out of quartz glass, which attracted considerable attention at a scientific congress held in Breslau in 1905. The strong odour of ozone revealed the quantity of ultra-violet rays produced in the vicinity of these lamps by their action upon the oxygen of the air. The spectroscopic test of the wave length of the light emitted showed that the rays possessed wave lengths up to the extent of 220 $\mu\mu$.† The question arises whether the high price of rock-crystal and its tendency to break would stand in the way of the general application, especially for medical purposes, of the quicksilver lamps. In the well-known glass works of Schott and Genossen, in Jena, Dr. Zschimmer had recently produced a peculiar kind of glass which readily transmitted ultra-violet light. Dr. Schott, the well-known colleague of Abbe, could, therefore, taking the new glass as a basis, bring about improvements in the mercury lamp, which answered the requirements of all scientific and practical purposes. Since the spectrum of the new glass composition called the "Uviol"—*i.e.*, ultra violet—of Schott attained the figure of 253 $\mu\mu$, this is quite sufficient, in fact perfect, for medical purposes, because the rays of very short lengths can be neglected on account of their very small power of penetration. The visible part of the spectrum only extends from 579 to 405 $\mu\mu$, and a long range of chemical active rays two-thirds of the length of the spectrum are here excluded. The special mercury lamps of Heraeus and Schott‡ are accordingly extraordinarily advantageous contrivances for transforming electrical energy into useful radial energy of small wave length. Since it contains rays of short wave length, this source of light will probably be of very great use in photography. The special mercury lamps of Schott (Uviol) and Heraeus (quartz) are excellently adapted for exposures and printing by artificial light in northern climates with their short and dark winter days. These lamps will also be of importance for the textile industry in testing the fastness to light of different dyestuffs.

The bleaching action of sunlight is a slow working chemical process, which is to be traced back to the action of the ultra-violet rays. The unfavourable climatic conditions in our regions compel the dye manufacturers to get their tests of the fastness to light of their colours carried out in the sunny South, since all kinds of artificial light—including also the electric arc light—do not produce the same result as the sun. The numerous attempts to carry out these trials with the Uviol lamp have turned out successfully, and the question of the fastness of colours to light will probably be settled in the future in the same number of days as formerly it took months to find out. The rays of the Uviol lamp exercise a striking death-dealing action upon small insects. A house-fly succumbed in one minute when placed about 1½ cms. from the source of the rays, in circumstances such that the heat could do no harm. Under a lamp which was placed by an open window in a room one summer's night, one could sweep up in the morning thousands of small dead gnats. Similarly, still smaller forms of life, such as bacteria, under the influence of the mercury lamp as with the sun, rapidly die.

The so-called fluorescent lamp, constructed by Dr. Schott, and recently brought by him before the scientific conference at Meran, is merely a variation of the Uviol lamp, in which a larger portion still of the long wave rays are suppressed and removed; it burns, therefore, somewhat dully; whilst the exterior and the attendance is the same as for the other lamps. In the light of this lamp everything appears pale and unreal. Whilst the lamp itself burns comparatively dull, it produces in its surroundings widespread fluorescence on different substances, for instance, rhodamine, fluorescein, and uranium glass, so that such substances give more illumination than the lamp itself. But vaseline, lanoline, soap, and the human skin also exhibit a peculiar play of colour. Since in the latter case changes in the skin imperceptible by daylight become visible, we, therefore, possess in the Uviol lamp not only an inestimable medium for therapeutic and pathological purposes, but also for diagnosis. This fluorescent lamp, which has, of course, a very considerable value for the furthering of physical science, will also be turned towards the treatment, by means of fluorescent solutions, of the so-called sensibility of light, which plays an important part in medicine. These operations are also to be explained by the chemical action of light, through the ultra-violet rays.

Hertz had discovered that ultra-violet light had the power of setting free negative electrons of a radiating body. Consequently the special mercury lamp will also produce ionisation; an electroscope brought into its neighbourhood shows this fact very clearly, which, like the fluorescence above described, reminds one very much of the properties of radium. In all work with the ultra-violet rays it is necessary to protect the eyes with spectacles in order to prevent serious inflammation of the eyes. Fifty years ago the French savants Regnault and Foucault advanced the view that the violet and ultra-violet rays might be injurious to the eyes, because they produced fluorescence in the humour of the eye, which fatigued the optic nerve, and altered the transparent cells of the eye. Since the quicksilver light is very reactive chemically, so the "sight-purple" of the eye, as König names the agent of vision, will be more used up by this illumination than by the methods of illumination formerly in vogue. For hygienic reasons those kinds of illumination which give a yellowish or reddish light are, therefore, to be preferred. Since the peculiar unpleasant colour of the light of the Hewitt lamp is the greatest drawback for its general use, great pains are being taken to compensate the colour of the light. The simplest way of overcoming this difficulty should be by means of the so-called "orthochrome" lamp * by combination of ordinary incandescent electric lamps, or by enclosing the mercury waves in red waves by means of the fluorescence of rhodamine. The most valuable property of the Hewitt lamp appears to me to lie in its property, discovered by Hewitt, of transforming a transmitted alternating current into a direct current.

Many attempts have already been made to replace mercury by other metals, but always with negative results; the powdering and deterioration of the negative electrode is just as bad with other metals. Also, by the use of other gases for preserving the mercury electrode no results worth calling have yet been produced. Werner von Bolton turned back to Auer's idea, and so came to the tantalum lamp. Tantalum is, like platinum, a metal whose melting point—2250 deg. to 2300 deg. C.—lies far higher than that of platinum, which has already been used by Edison for incandescent lamps, but without any success. Like osmium, it has the property as metal that its electrical resistance increases on heating. At ordinary temperatures it amounts to 0·165 Ω, for 1 mm. length and 1 square millimetre diameter; at the ignition temperature of the lamp, on the other hand, 0·850 Ω. The tensile properties of tantalum in the cold state are very good—93 kilos. / square millimetre, the corresponding figure for good steel, is, according to Kohlrausch, 70 to 80 kilos. / square millimetre—so that it can be rather easily worked; on heating, however, it becomes, like osmium, soft, and after 200 or 300 hours burning, very brittle. The diameter of the filament is 0·05 mm. to 0·035 mm.; at 0·05 mm. a 25 candle-power lamp for 110 volts requires a filament length of 650 mm., which weighs 0·022 grammes, so that 1 kilo. of tantalum metal will make 45,000 lamps. To bring such a length into curved form, as in carbon filament incandescent lamps, is practically impossible. The osmium lamp, which was only used with comparatively low voltage, had the same defect if the curved form were preserved. The beginning of the tantalum lamp consists, therefore, in the application of a frame on which the necessary length of wire is wound. The patents of Siemens and Halske and Scholvien—German patent 159,096—relating to this may include all possibilities in the application of long metal wires for incandescent electric lamps. A process has also been protected by Siemens and Halske to manufacture fused tantalum from the amorphous variety, as well as the application of drawn tantalum wire, and wire from other difficultly-fusible metals, such as zirconium, thorium, yttrium, and erbium—German patents 165,057, applied for October 14th, 1904, granted November 24th, 1905;

* See THE ENGINEER, January 10th, 1903.
† (1 $\mu\mu$ = 0·000,001 mm.)
‡ See the *Chemiker Zeitung*, 1905, page 4, on the Uviol lamp.

* See THE ENGINEER, January 20th, 1905.

169,565 of May 3rd, 1903, granted April 5th, 1906—for incandescent electric lamps. In order to prevent any possibility of the formation of carbides which would bring about the rapid destruction of the lamp, the pulverised amorphous metal is pressed without the aid of any organic binding material into discs or pads, and then fused in the electric arc in the absence of air or in the presence of some inert gas.

A piece of tantalum heated to redness is transformed under the steam hammer into a thin metal plate, which by heating to incandescence and hammering acquires a hardness like hardened steel, although it still remains flexible.

Siemens and Halske intend to manufacture tools and other articles out of tantalum alloys, and the German patent No. 167,217 granted to this firm means, perhaps, the end of an extensive, and since the twentieth year of the last century, vigorous industry. The tantalum pen is said to have a great resistance against chemicals, to be much harder and more elastic than the steel pen, and on account of this hardness and elasticity, to be indestructible. It exceeds in elasticity the well-known gold nib of the fountain pen, and so these two kinds of writing pens will soon be supplanted, if they succeed in manufacturing tantalum metal at an acceptable price.

In the last annual report of Siemens and Halske it is stated that a large laboratory for the chemical and metallurgical part of tantalum production will be set to work in the early future. Since the obtaining of tantalum mineral now gives no great difficulty, and almost any quantity can be bought cheaply daily, it is to be hoped that the most modern branch of industrial chemistry will soon occupy itself in the valuable production of tantalum metal.

CONTINENTAL LOCOMOTIVES AT THE MILAN EXHIBITION.

SUPERHEATING FOUR-CYLINDER COMPOUND LOCOMOTIVE, AUSTRIAN STATE RAILWAYS.

WHAT is probably the largest engine of "goods" type with non-articulated frames that has ever been built for a European railway is illustrated in Fig. 3, page 571. It is a four-cylinder compound, using superheated steam, and having, by continental formula, a maximum tractive effort of 16 tons. This very powerful engine is designed expressly for mountain inclines and for hauling all descriptions of trains, and, in particular, express passenger trains. Its chief service will be on the mountain gradients of the State Railways of Austria, as also, presumably, of the Semmering line, and it is worthy of remark here that, although in the great Semmering locomotive competition of 1857—fifty years ago—nearly all the engines entered were of double bogie or other flexible arrangement, the locomotives in later periods have always, in their time, been the most powerful in Europe, having rigid frames and ordinary mechanism; and this, notwithstanding the fact that the axle-loads have been limited to about 13½ tons only. By the employment of very powerful locomotives of this description for working the express trains of mountain sections it has been possible to avoid to a large extent the double traction—with a rear pusher—that is so prevalent on continental main lines having gradients of over 1 in 40, on which tractive efforts of 20 tons—by low-value continental formula—is oftentimes necessary.

Sufficient flexibility for passing curves of 600ft. radius has been obtained in this engine by an arrangement introduced, we believe, by the designer of the locomotive illustrated—Mr. Karl Goelsdorf—which has been much followed, under his guidance, by other continental engineers. This consists in allowing direct lateral movement to certain of the driving wheels. In this new engine, of series 280, the second and fifth driving axles are allowed 1in. play on either side, and the main driving wheels—third axle—have no flanges. The total rigid wheel base is thus reduced to 16ft. 9in., the two intermediate bearings on the rail being free to adjust themselves to the curvature within that length. The total driving-wheel base is 21ft. 9in., and the entire wheel base is 28ft. 4½in. The small leading wheels have Adam's radial axle-boxes, giving 2in. displacement on either side. In preceding five-coupled engines built for the Semmering division of the Southern Railway (Südbahn) the axles of the first, third, and fifth pairs of driving wheels have a lateral play of 1in. on either side, and in those engines all tires have flanges as usual. They are two-cylinder compounds. The engines now illustrated are, as already stated, four-cylinder compounds, having all four engine motions balanced upon one axle, according to present approved practice. The crank axles in this engine are of the oblique pattern, square in section, 10⅝in. by 7⅜in., forged in nickel steel, with crank cheeks of Worsdell type. In the preliminary forging the "lobs" for the formation of the crank webs are usually parallel with each other; but after subsequent shaping under the hammer they are twisted to their definite angle of 90 deg. The outside driving pins in the wheels are set, as usual, at 180 deg. in relation to each nearest inside axle pin.

In order to enable the crosshead of the inside high-pressure piston, as also its connecting-rod, to clear the second coupled axle, without resort to any special form for the rod, the cylinder casting is inclined at an angle of 1 in 8. At the same time the piston is made to reach, in backward stroke, to behind the second driving axle, so that a connecting-rod of only 6ft. 7½in. in length is employed, although the outside rod of the low-pressure cylinders is as much as 11ft. 1½in. long. The piston stroke is the same in both groups. All the cylinders are set on one transverse line, the high-pressure being inside, according to general practice. Cylinders, valve chests, and boiler saddle are cast in two pieces bolted together at the centre line of the engine. There is only one set of valve mechanisms of Walschaerts's—Heusinger—type, the inside valves being worked through special rocking levers, which effect the reversal of movement necessary for admitting steam by the outside edges of the slide valves. The radius rod is curved slightly downwards to clear the bracket of the low-pressure valve spindle guide. This detail is not visible from the outside, as a short outrigging frame for the support of all the valve motion conceals part of this latter.

The engine always works compound, and therefore has no intercepting valve. It has, moreover, no starting valve for live steam admission to the low-pressure cylinders. Instead, there are perforations in the valve-chest faces—Goelsdorf arrangement—which admit steam direct to the low-pressure cylinders when the cut-off exceeds 80 per cent. of the piston stroke. Prompt starting in all positions of the cranks is also favoured by a very late cut-off. All valves have an outside lap of 1¼in. The high-pressure valves have $\frac{7}{8}$in. inside lap, and the low-pressure valves are set line and line. Combined air suction and relief-pressure valves are provided on the receivers.

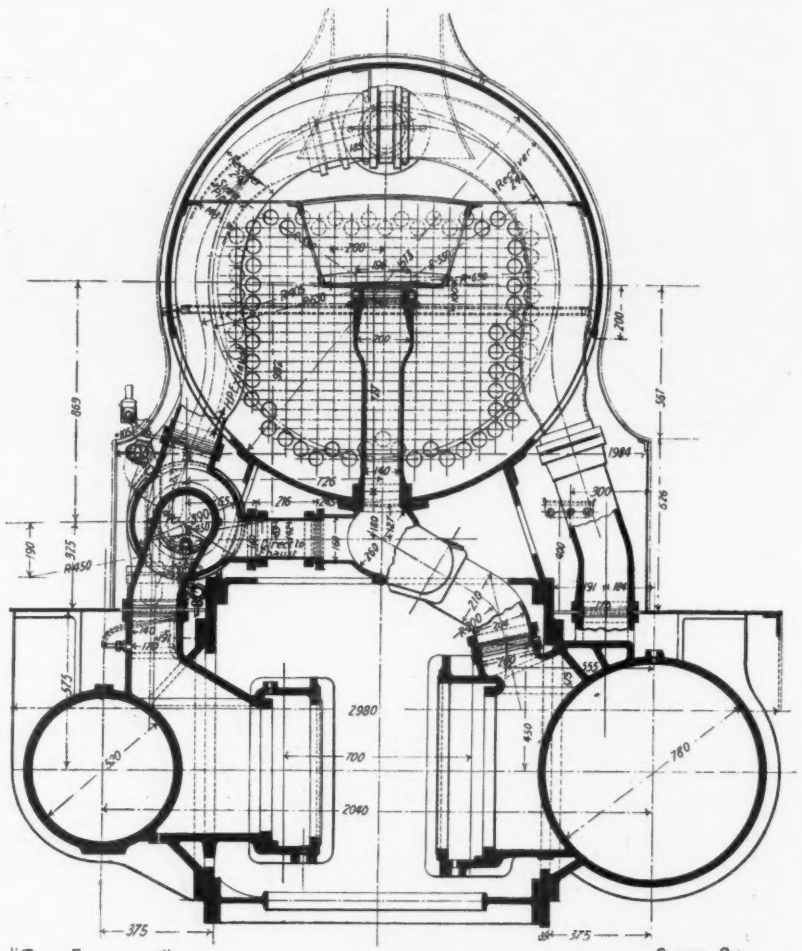


FIG. 1—SECTION THROUGH CYLINDERS, BORSIG COMPOUND

For the reduction of steam back pressure on the high-pressure pistons the low-pressure cylinders are designed with a volume of 2·93 times that of the high-pressure cylinders. The piston speed when the engine is working hardest—this corresponding to the rate of 20 miles per hour while hauling trains of 280 tons weight behind the tender up inclines of 1 in 40—is not high. The maximum speed for which the engine is designed is 44 miles per hour, and the corresponding piston speed would, therefore, occur upon falling gradients just when the total back pressure on the larger pistons would be quite immaterial.

As mountain lines usually abound in curves of short radius, the keeps of the axle-boxes have been designed to avoid binding and consequent straining of the horn-block guides due to oblique movements of the axles. For this purpose the axle-box flanges, or keeps, are not parallel to each other, viewed endwise, but have a clearance both at top and at bottom. The width between the keeps at the middle is 5in., and at top and bottom 138 mm.—nearly 5½in. As the depth of the boxes is 15½in., the inclination corresponding to these differences in widths is 1:30·9 from the centre, upwards and downwards.

All the axle springs of the engine are connected longitudinally by equalising levers—each pair of axles, from leader to trailer, being equalised. The coupling pins of those axles having side play allow of an equal movement in the coupling-rod brasses. These rod ends mark a new

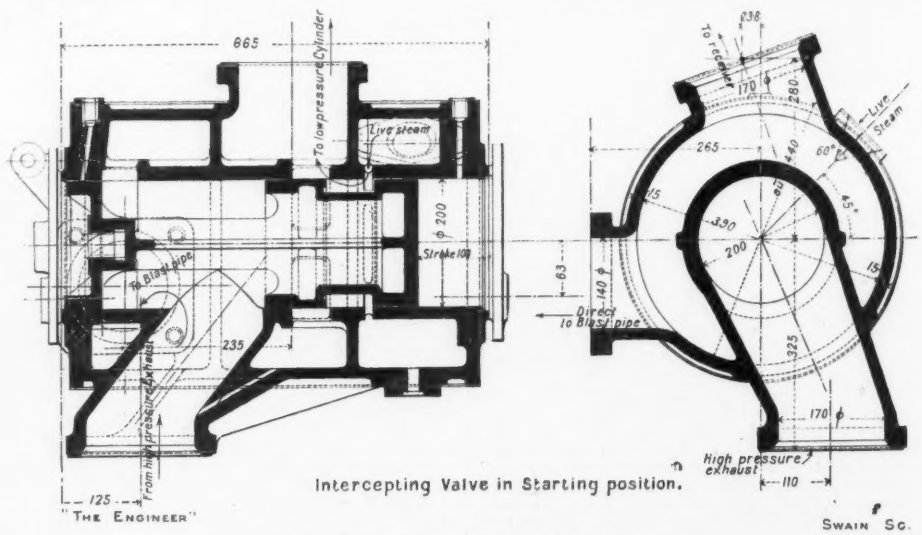


FIG. 2—DULTZ-BORSIG INTERCEPTING VALVE

continental practice, for, despite the objections hitherto urged against their use, they are simply plain bushed eyes without adjustment for wear. The piston crossheads are single-piece steel castings clasping the single-guide bar and lined throughout with bronze; the guide bars are of ⊥ section.

The boiler is of modern construction. It is remarkable for the new system of superheater by Mr. Goesldorf contained in the first of the three rings composing the boiler

CONTINENTAL LOCOMOTIVES

(For description see page 570)

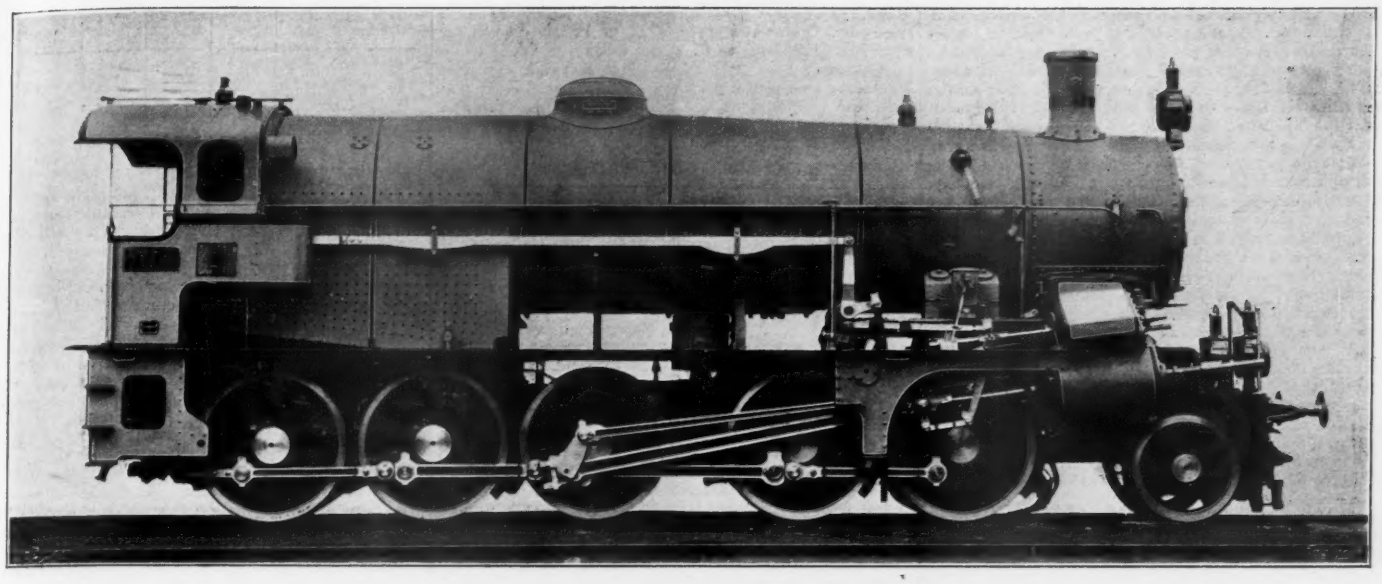


Fig. 3—FOUR-CYLINDER COMPOUND LOCOMOTIVE—AUSTRIAN STATE RAILWAYS

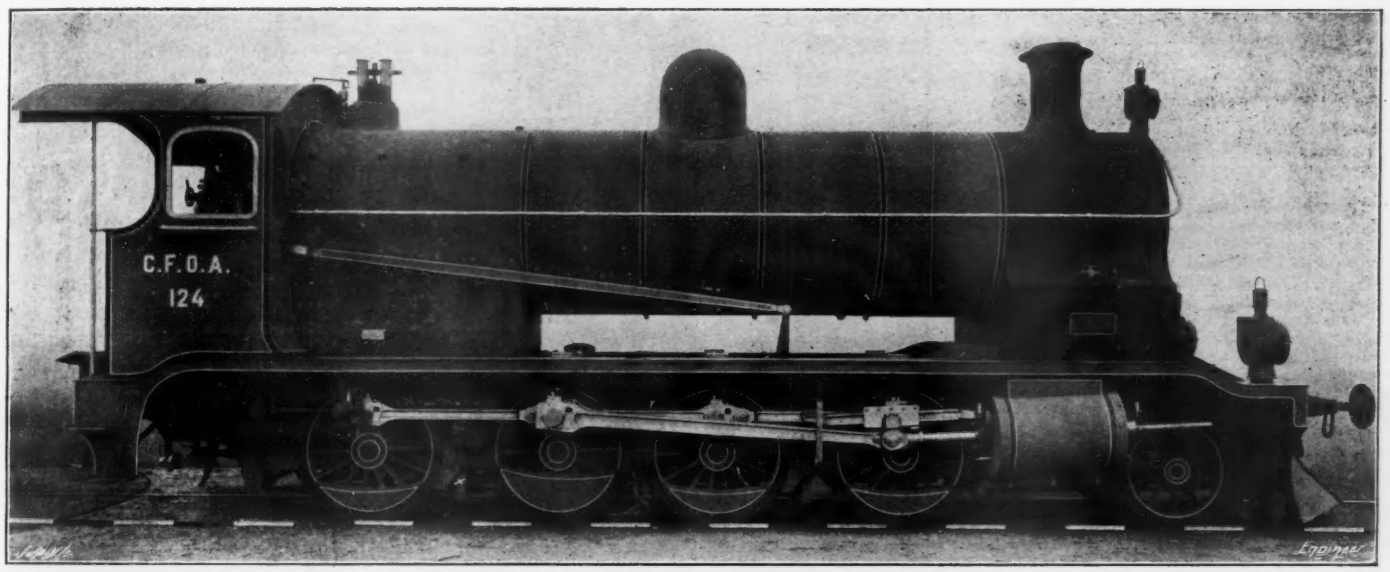


Fig. 4—COMPOUND GOODS ENGINE—ANATOLIAN RAILWAY

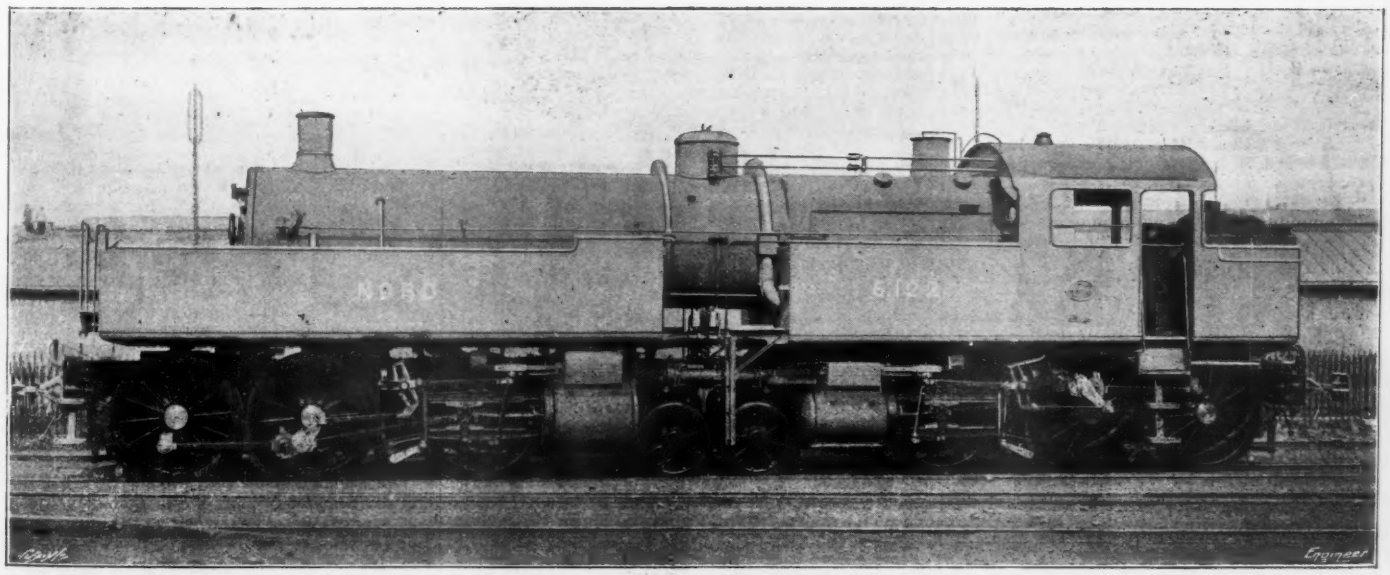


Fig. 5—DOUBLE MOTOR BOGIE GOODS ENGINE—NORTHERN RAILWAY OF FRANCE

barrel. In this superheater is fitted the regulator valve for admitting dry steam direct to the high-pressure cylinder. The steam dome in this case merely serves as a collector for the steam pipe delivering to the superheater. The regulator valve is a simple slide working over a port 5¼in. in breadth and with a length varying from 2in. at the sides to 2½in. in the middle to ensure a gradual increase of sectional opening. The new superheater was tested some two years ago in a Mogul compound, and the results thus far obtained are said to have been very satisfactory. The boilers of the new series 280 are unusually large for European practice. Their capacity is 370 cubic feet, of which 211 are for water and 159 for steam. The boiler is fed with two No. 9 S. T. Friedmann re-starting injectors; the round fire-door is provided with the Marek air deflector, which effectively prevents smoke; cylinders, valves, and piston packings are lubricated by two Friedmann oil pumps, of 6 litres capacity, worked from a link on the piston crosshead. These are heated, in winter time, by steam from the steam sanding apparatus, which is of the Rihosek type. Speed is indicated and recorded by a Hausshaelter tachograph actuated from an extension on the rear end of the coupling-rods. The brake employed is the Hardy rapid-action vacuum, 1902 pattern; and the speed bands from the tachograph show that in descending long mountain inclines it maintains the speed at a remarkably unvarying rate. The conduct of fast international trains by these locomotives of goods-engine type in traversing the magnificent hills of the Semmering, the Brenner, or the Arlberg, creates an all-round impression of well-ordered conditions superior, if anything, to those of Italo-Swiss and Franco-Swiss main line mountain services. In a run from Venice to Vienna, through Carinthia and the iron mining district of Leoben—at the foot of the Semmering—the engineer forms a high opinion of Austrian railways, their maintenance and traffic working under the most widely varying topographical conditions to be found in Austria.

The following are the leading particulars of the series of engines:—

Dimensions.

Cylinders—	
High-pressure (2)	·370 m.
Low-pressure (2)	·630 m.
Piston stroke	·720 m.
Boiler pressure	16 atm.
Driving-wheels diameter	1·450 m.
Maximum tractive effort	16 tons.
Boiler—	
Grate area	4·6 sq. m.
Tubes, 291 of 48-53 mm. diameter, length	3·680 m.
Heating surfaces (outside) fire-box	15·5 sq. m.
,, ,, ,, tubes	179·5 sq. m.
,, ,, ,, superheater	63 sq. m.
,, ,, ,, Total	258 sq. m.
Barrel, largest inside diameter	1·757 m.
,, height of centre from rail (at back)	2·460
,, ,, ,, (in front)	2·890
Chimney height from rail	4·570
Weight of engine empty	70 m. tons.
,, ,, fully loaded	77·2 m tons.
,, (maximum) for adhesion	67·4 m. tons.

GOODS ENGINE, ANATOLIAN RAILWAYS.

The eight-coupled goods engine shown in Fig. 4, page 371, was designed for gradients of up to 1 in 40, which, on the Anatolian line of the Ottoman Railways, occur between Biledjik and Ine-Oeunu. This line, it may be added, extends from Haidar-Pascha in the Bosphorus to Angora and to Konia, and is interesting in that it will before long probably form a part of the trunk line Constantinople to Bagdad and to the Persian Gulf.

The engines of the type illustrated have taken the place of previous engines having six-coupled wheels and others of eight wheels—coupled 4 + 4 in articulated frames. They were designed and built by A. Borsig, of Berlin-Tegel, in 1904, and have completely fulfilled all conditions required of them in regular service. The minimum radius of curves is 670ft., and this in a locomotive having a coupled wheel base of 14ft. 9in. has been met by allowing a direct lateral play, in the axle-boxes and coupling-rod brasses of the second and fourth axles, of 11 mm. and 13 mm. respectively. The leading truck axle has a radial displacement on either side of 1¾in., controlled by a coiled spring with traversing pin.

In the constructional details there is no departure from practice common in England, except, perhaps, that the tube plate is circular and flanged. The slide valves are flat and placed inside the frames, and the Allan link motion is driven from inside excentrics on the third driving axle, the excentric rods being bent to clear the second coupled axle. Single crossheads were employed because with double guide bars the motion plate would have exceeded the construction gauge of the railway. For the same reason the outside cylinders were inclined at 2 in 41. A cross section is shown in Fig. 1.

The principal detail calling for attention is the Dultz intercepting valve for working the engine compound or non-compound at will. This has the form of a cylindrical slide valve with a longitudinal travel of 4in., as shown by the detail drawing. It is non-automatic—see Fig. 2.

Air-suction valves are provided on the cylinder valve chests, and a relief pressure valve, set at 65 lb., on the low-pressure valve chest. The engine is also equipped with two 3in. safety "Pop" valves; Friedmann's oil pump, for cylinder oiling, driven from one of the excentrics; Friedmann's "combination" injectors; Hausshaelter's speed indicator and recorder, run from the rear driving wheel; Gresham's steam sander; steam brake applied to the second and fourth pair of drivers, and with the brake-block hangers suspended from double joints, this allowing the blocks to follow the lateral displacements of the wheels. In the dome the regulator valve is of the double-seated or balanced type. A hole with trap is provided in the front of the smoke-box plate for clearing out the bottom of the smoke-box, which is of D section. The various steam pipes therein are of mild steel. The cab has a double roof, and has two doors in front giving access to the running board on each side. The front of the engine is provided with a "cow-shovel," for the Anatolian lines are not fenced. This serves also as the support for sheet iron plates which convert it into a snow shovel during the winter months, when the snow-falls are deep on the higher table lands traversed by the line.

These engines are designed for maximum loads of only 13½ metric tons per axle on account of the lightness of the rails. With the heaviest of trains the tractive effort exerted sometimes amounts to one-fifth the weight available for adhesion. On gradients of 1 in 39 they can pull trains of 200 tons at a speed of 11 or 12 miles per hour, or trains of 180 tons at 17 to 18 miles per hour; while on grades of 1 in 70 they have even taken trains of 400 tons. One of the most recently built engines of this class was exhibited by the builders at the recent Milan Exhibition.

Dimensions.

Cylinders—	
High-pressure	20⅛in.
Low-pressure	30⅝in.
Piston stroke	24⅛in.
Driving wheels diameter	49in.
Leading wheels diameter	38⅛in.
Boiler pressure	185 lb.
Grate area	24½ sq. ft.
Heating surfaces	1710 sq. ft.
Weight, empty	54⅜ tons
Weight, fully loaded	61 tons.

The six-wheeled tender weighs 14¾ tons empty or 31½ tons when fully charged. It carries 2650 gallons of water and five tons of coal.

DOUBLE-BOGIE EXPRESS COAL LOCOMOTIVE, NORTHERN RAILWAYS OF FRANCE.

A view of a new type of duplex locomotive at work on the Chemin de Fer du Nord of France is shown in Fig. 5, page 571. In addition to the specimen shown at Milan, several others are being constructed. The engine exhibited had the tanks on one side dismounted, thus permitting free inspection of constructional details inside the frames.

Duplex engines with articulated frames, or articulated driving gear with rigid frames, have quite recently been adopted in some notable instances for the heaviest main line traffic, both goods and passenger. Hitherto articulated locomotives have been mostly confined to narrow-gauge lines laid with very sharp curves, and their lateral flexibility saved so much resistance on these curves that their draw-bar pull exceeded that of correspondingly powerful engines having rigid frames or ordinary rigid driving mechanism. With the greatly increased length required for goods engines the duplex type of locomotive are coming into much more general use on the Continent, at all events, for the heaviest traffic of main lines; for saving of resistance on curves always means increase of the power available at the draw bar.

M. du Bousquet is, however, not the first chief engineer to introduce duplex four-cylinder locomotives on the Chemin de Fer du Nord of France, for M. Petiet, his predecessor, designed ten duplex four-cylinder locomotives in the year 1862. They had, however, this important difference as compared with those at present under consideration—that the frames were rigid, though the number of driving and connected wheels were the same in each case—that is, twelve. These locomotives were exhibited at the London International Exhibition of 1862. They had wide Belpaire fire-boxes carried over the frames, water tanks forming a saddle below the boiler, and superheaters above the top of the boilers. The superheater was merely termed a "steam-drier;" but in principle, though not in intensity, it differed little from previous or subsequent superheaters. Some of these former superheater engines may still be seen, slightly modified, at work upon the Nord lines, together with great numbers of the much older engines illustrated in our Supplement of June 20th, 1890, and all, apparently, still doing excellent service.

Then the engine was built of forged iron; to-day it is of cast steel to an unusual extent, with nickel chrome steel of extraordinary tenacity for the working parts. The driving and coupled axles, the driving wheel pins, and the coupling-rod pins are of nickel chrome steel specially manufactured at the Creusot works of Schneider and Co. These pieces are hardened and annealed, and when tested give proof of exceptional quality with a very high elastic limit, great resistance, a notable elongation, and a decided contraction. The texture of the metal is radically transformed by the hardening process, the grain becoming fine and sinewy, and exceedingly tough. The tests show that nickel chrome steel is almost insensible to reversal stresses, and especially suitable for pieces subject to violent and repeated stresses and incessant vibrations. Various experiments have shown that this steel has a much greater tensile strength than the best carbon steels of an equal hardness.

A series of test pieces gave the following results:—

	D, and L. 15·0.	Elastic stre gth per sq. mm.	Tensile strength per sq. mm.	Elongation per cent.	Contraction area per cent.
		kilos.	kilos.		
Axles	100	55	71·6	17·1	62·6
	100	56·6	73	17	61·6
Driving and coupling pins	100	58·0	72	17·6	63·2

The axles have a diameter of 7½in. The main feature of novelty in this engine is the central frame, of box-girder type, rigid with the boiler. This is built up of mild steel plates and angles, and is not, with the engine fully loaded, submitted to a greater stress than 4 kilos. per sq. cm. Notwithstanding the great length of the engine, it is able to traverse curves as short in radius as 300ft. with perfect ease. These new locomotives are to replace the 4-6 four-cylinder compounds in the fast freight service between Lens and Paris—230 kilom.—in hauling loads up to 1000 tons. The latter engines, employed also in passenger service, are accustomed to pull 950 tons in goods service, although they only have a maximum adhesion of 44 tons, and a maximum theoretical tractive effort of 10½ tons working compound, or 13½ tons working single-expansion. They weigh with tender fully loaded 97 tons. The double-bogie engines, with a medium adhesion of 80 tons—half-full load of coal and water—have maximum tractive efforts of 18 tons compound, and 24 tons single-expansion; yet the whole engine with its supplies only exceeds by 5 tons (= 102 tons) the ordinary fast goods engines of Class 3.121—3.235. In addition, the new engines now mount the 1 in 83 gradients between Busigny and Hirson without dividing the trains as heretofore. On gradients of 1 in 77 they pull trains of 800 tons at 12 miles per hour, and run up to speeds of 47 miles per hour with perfect smoothness. The various flexible steam pipes have so far kept steam-tight; and, in general, this combination of the tender with the main engine frame, including the necessary duplication of the engines on two bogies, appears to be so far practical that it is likely to become a standard type for all goods engines of great power on the Nord lines. In order to keep the load equal on the two bogies—however much the coal and water supplies are reduced—the principal charge of water is carried by the front bogie truck—that is, 9 cubic metres—whilst the remainder, 3·8 cubic metres, is carried in the small tanks at each side of the fire-box on the engine main frame. The bunkers at the back of the cab have a capacity for 5 tons of briquettes. The front tanks are almost triangular in cross section, in order to allow the boiler due clearance when the front bogie is deviated from its direct course. In a locomotive of such great length it was an important condition that the front bogie truck should turn freely about a longitudinal axis and so adapt itself, independently of the rear bogie, to the cant of the track on entering and leaving curves. The details given in Fig. 6 show the form of universal pivot adopted here. To limit the motion, and to steady the front end of the boiler, oblique buffing attachments, supported on rollers against the upper edges of the front bogie frames, are employed, as shown in the transverse section of the pivot. All the stresses of the draught and train buffing gears are taken exclusively by the central rigid frame, and in no case by the bogie trucks, even when the engine is run cab first. It is obvious that the engine could be run almost equally well with either end leading, although with the greater flexibility of the front truck it is preferable to advance with the chimney in-front.

The two sets of engines and their mechanisms are identical. All the rods are left as forged, except the big ends, which are machined. All the steel castings, of which the engines are largely built, are left in the rough. The slide valves are flat and semi-balanced, according to a special practice of the Nord whereby the valves work under the conditions of unrelieved valves when the regulator is closed, so avoiding the resistance to which ordinary relieved valves are subject at such moments. The regulator valves in the dome are double, one for the high-pressure and one for the low-pressure cylinders, each worked by a separate handle in the cab. The reversing screw is operated either by hand power or by a

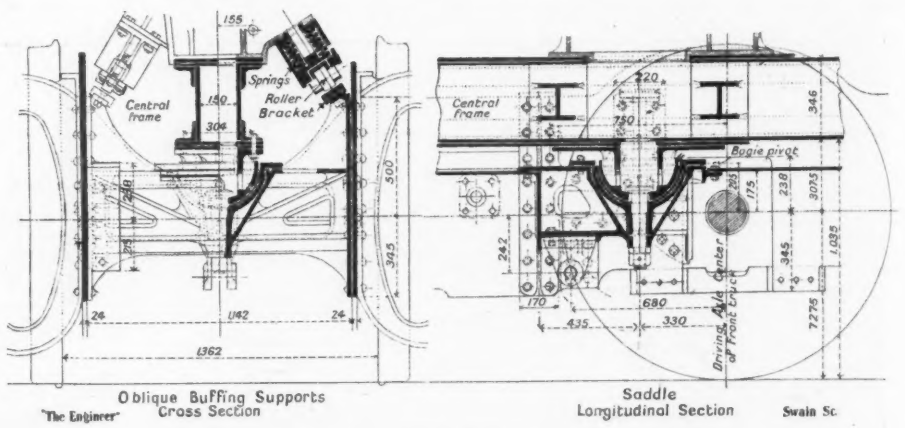


Fig. 6—PIVOT OF DUPLEX LOCOMOTIVE

compressed air motor contained in the reversing wheel. As each reversing mechanism is carried upon a frame distinct from the rigid superstructure to which the main reversing screws are attached, it follows that a considerable range of movement between three points of fixture must be allowed for, and this is effected by sliding feathers and bevel pinion gears on the main frame, and on the bogies by screws fixed to articulated bearings in connection with flexible joints, allowing of rotating movements whatever be the position of the bogie trucks.

In addition to working the reversing gear, compressed air is employed for the intercepting or change valve—Nord pattern—for the rail sander and for the drain cock mechanisms of the four cylinders. For the serving of these motors there is a small Westinghouse pump, regulated to 94 lb. per square inch, and connected with two reservoirs for this special purpose.

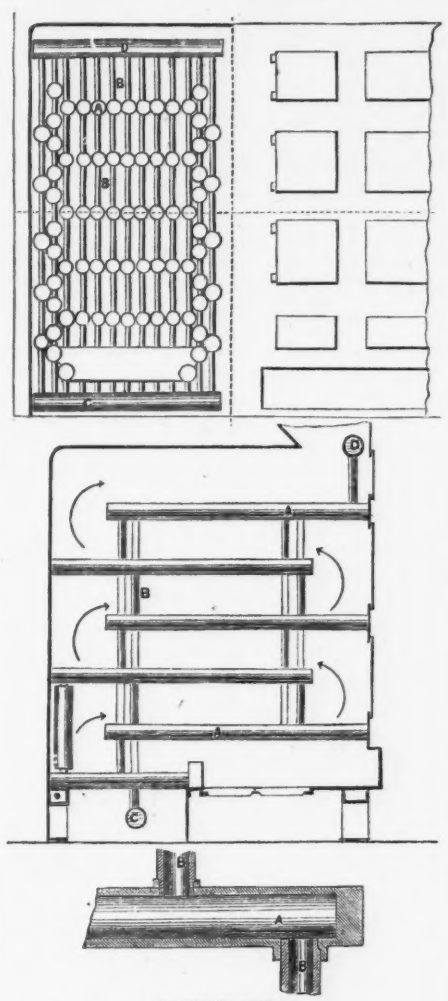
THE INSTITUTION OF MECHANICAL ENGINEERS.

THERE was a large attendance at the Institution of Mechanical Engineers last Friday evening to hear the resumed discussion on Mr. Thomas Clarkson's paper on "Steam as a Motive Power for Public Service Vehicles." The paper was reproduced in THE ENGINEER in our issues of November 23rd and 30th. The first speaker was Mr. Hans Renolds, of Manchester, who confined his remarks to the superiority of the chain drive over the live axle. He was delighted with Mr. Clarkson's simple method of transmitting the power from the engine to the road wheels, and referred to the illustrations in the paper, which showed this method, and a comparison was made with the gearing adopted with those used on petrol vehicles. Mr. Renolds alluded to some defects of chain drives as at present used, and explained how Mr. Clarkson had avoided them. He stated that chains were noisy only when either a wrong type of chain was used, or when the sprocket wheels were too small. Mr. Clarkson used on his omnibuses 19, 20, and 21 teeth, and repeated reference had been made at the last meeting to the silent running of the Chelmsford car. He (Mr. Renolds) had known cases where 9, 8, 7, and even 6-teeth sprocket wheels had been used, which were unreasonably small, and had been fitted in spite of the protest of chain specialists. Another objection frequently urged against the use of chains was that they broke. This was said to be the case only when inferior metal was used, or when the chains were really too weak for the work they had to do. Some engineers believed that chains wore out quickly and stretched a lot. This, again, was only true when the chain had to run on sprockets too small for the purpose, or when the distance of the sprocket centres was very short, or when the oiling and cleaning of the chain was neglected. Frequently there was no protection whatever given to the chain against mud splashing from the road when the vehicle was running, or when it was washed down with a hose. Often all these conditions existed together, and it was not surprising that the best results with chains were not obtained. It was stated that the life of a chain was proportional to its length.

Professor Spooner followed. He referred to Colonel Crompton's early experience with steam vehicles, and also to that gentleman's remarks concerning the Perkins boiler. We reproduce a diagram of the boiler which appeared in THE ENGINEER for November 22nd, 1861. It consisted of a number of horizontal straight wrought iron tubes A, welded up at the ends, and connected with one another by smaller vertical pipes B, as shown enlarged in the bottom illustration. These tubes contained the water to be evaporated and the steam. The fire played outside them. The boiler contained five layers of the larger tubes, which were 2¾in. in internal diameter and 3in. in external diameter. The connecting pipes were ⅞in. internal diameter and 1⅜in. external. When working, the water line was supposed to be in the centre layer of tubes, as shown by the dotted lines in the diagram. The hot gases from the fire passed backwards and forwards between the layers of tubes—the passage being indicated by the arrows—and they remained sufficiently long in contact with them to allow of a very good absorption of the heat. The several layers of tubes were connected together at the bottom by means of a cross tube C with connecting pipes to each section. The steam was taken off through a similar cross tube D at the top of the boiler with a connecting pipe to the highest tube of each section. Each section was tested up to 3000 lb. per square inch. Professor Spooner observed that he had had experience with this boiler, and had found it most satisfactory. It had, he said, remarkable properties. Whatever kind of water was used, there was no incrustation. In 1874-5 a Boiler Committee appointed by the Admiralty examined a Perkins boiler that had been in use for thirteen years, and were astonished at the remarkable state of preservation of the tubes. He considered that the system of lubrication adopted by Mr. Clarkson was splendid, especially with regard to oiling the cylinders. In the Perkins engine no lubricant was used at all—in fact, there were no good oils then. And yet the valves, which were of the piston type, were found to be in perfect working order after considerable use. Probably it was due to the special antifriction metal which was used. It was composed of 5 parts of tin and 16 parts of copper, an alloy which proved to have many excellent properties.

The next speaker, Mr. G. de Prelle, the engineer of the London Road Car Company, referred to the flexibility of the present petrol engines. It was stated that they could now be throttled down to run at 100 revolutions per minute, or allowed to run as many as 1300 revolutions per minute. The great drawbacks with petrol omnibuses were the gears. Due to the very rough handling they underwent at the hands of inexperienced drivers, they soon became very noisy. In order to obtain a silent change of gear the circumferential speeds of the pitch circles of the two pinions that are to be put into mesh must be the same. Mechanism for fulfilling this condition was complicated, and so engineers had gone to the other extreme and stopped the gears altogether, whilst they were being changed. A clutch stopped one shaft between the engine and the gear-box, and another device was fitted between the gear-box and the differential gear which worked in unison with the front clutch. So that, by throwing out the front clutch, the omnibus was practically allowed to "free wheel." He had tried this system for two months, and excellent results had been obtained. They had had no accidents with the omnibuses so fitted, and when the gears were taken out for inspection they were found to be as good as new. Mr. De Prelle then discussed the materials used for making gear wheels. On one shaft of the gear-box he had used phosphor bronze and on the other mild steel. These gears, he said, were still good. Their advantage lay in the fact that no hard steel particles could become mixed with the oil. For when this did occur they found their way into the bearings, which then soon became worn and consequently noisy.

Mr. Vaughan Pendred said that he would not occupy the time of the meeting more than two or three minutes.



PERKIN'S BOILER

He wished to make a statement and ask a question or two. Mr. Clarkson had illustrated in his paper, on page 34, a boiler of the Locomobile type. His—Mr. Pendred's—son, a doctor, had used a Locomobile car for a couple of years. Mr. Pendred desired to submit to the meeting a copper-flue tube cut out of the boiler. It was 14in. long, and ½in. diameter outside. It was one of about 260 set in a shell 14in. diameter. The water space between the tubes did not exceed ⅛in. It might be supposed that such a boiler would be speedily choked with deposit; but it would be seen that the tube was absolutely clean. It had been in use for about two years, and the car had run some 4000 miles. Any clean water that came handy was used. What became of the deposit he could not tell, unless it passed through the engine with the steam. As bearing on this point, he might say that if a vessel, say a table spoon, had "hard" water put in it cold and evaporated, the lime salts in the water would adhere to the spoon. If, however, the spoon was first heated very hot and the water then dropped into it and evaporated, the deposit would be loose and flowing. It might well be that the temperature of the tubes in a Locomobile boiler would be much higher than that of the water. He wished to ask for some explanation of the cause of the enormous resistance offered to the motion of a dry Locomobile piston in a dry cylinder. He had taken off a cylinder cover and found that it was as much as he could do to push down a piston 2¾in. in diameter. The entire resistance was that of two Ramsbottom piston rings about ¼in. wide and $\frac{3}{16}$in. thick, which could readily be compressed by the finger and thumb. The surfaces of the cylinder and the rings were like mirrors. A few drops of oil sufficed to make the pistons fall by their own weight. He had spoken to various makers of steam motor cars, and they had one and all had the same experience, most of them fitting special little hand or steam pumps to force in oil from time to time. The facts set all theories of friction at defiance. Lastly, he begged leave to ask Mr. Clarkson of what steel his boiler was made. Experience with the Serpollet boiler and some of the small tube torpedo boat boilers showed that only nickel or the very highest class Swedish steel could be got to last. Was this Mr. Clarkson's experience?

Mr. Stephen Terry expressed the view that the introduction into this country of the motors of France and Germany, which had been so far chiefly made with the petrol engine, as the motor was the primary cause of the amazing prejudice which existed in certain quarters against steam. He remarked that Mr. Clarkson had given to the members of the Institution the results of years of patient scientific work, and he appeared to have successfully solved the problem of the petroleum burner, which was able to use the oil of commerce procurable everywhere at half, and less than half, the cost of petrol, and he had shown that with this as fuel the cost was only 1·15d. per mile in one of the most hilly districts in England. Mr. Terry agreed with Mr. Clarkson that it would be preferable if the products of combustion were discharged upwards. The steam car worked better with a chimney, as it added immunity from flame troubles. The arrangement of working the pumps of all kinds in the Chelmsford omnibus—from the countershaft running at a much less number of revolutions than the crank shaft, was a good feature. Most of the feed water troubles of the earlier and too lightly built steam cars arose from the pumps, which were apparently expected to pump water satisfactorily at speeds up to 1200 revolutions per minute. Hence the need for the hand pumps at the most inconvenient times. Heating the feed water was also of great importance, and when some thirty-eight years ago Messrs. Brown and May, of Devizes, fitted a feed heater to their portable engine, using the heat from the exhaust steam and recovering some of the water, they at once attained an efficiency of 15 per cent. over cold feed. Yet the earlier steam cars were innocent of a condenser and feed-water heater. There could be no doubt of the advantages of compounding the engines of a steam omnibus, especially as they fall into the hands of men who would not be put in charge of a large stationary engine or locomotive—men who had an inherent disbelief in the economy of linking-up, and who could not be brought to look upon the reversing lever and quadrant as anything beyond an application for producing forward or backward motion. Mr. Terry asked Mr. Clarkson if he had introduced a "hunting" cog in his spur gear. He held that it was just as important as in a chain drive. The pitch chain had done much for engineers in enabling them to have proper and elastic transmission, which a chain alone seemed to give. By hunting cog he meant that there was one tooth more or less in the large driving wheel than any multiple of the number of teeth in the pinion, and, therefore, one got a complete cycle of revolutions as many times as there were teeth in the wheel before the same link of the chain got into the same tooth of the chain. In his opinion it was undoubtedly a good thing to have a hunting cog, and nearly of equal importance with spur or bevel gear as with chain drive. He was of opinion that the prejudice which existed in some quarters against chain drives owed its origin to the neglect of the designers in failing to provide a hunting cog. After briefly referring to the excellence of Mr. Clarkson's oiling device, Mr. Terry concluded by suggesting an alteration in the design of motor omnibus bodies. With their present size and seating capacity, he thought the time had arrived when there should be a separate ingress and egress. Could such be arranged, one source of danger and delay would be removed, and much time saved.

Mr. M. H. Smith observed that all former steam omnibuses lacked proper oiling, a defect which Mr. Clarkson had ingeniously overcome. With regard to generators he had little to say. He made a comparison between the control on the White and on the Clarkson systems. The former controlled the oil passing through the vaporiser, and the latter the amount of gas which passed through the nozzle. He particularly liked Mr. Clarkson's scheme, but objected to the method of putting it into operation, owing to the number of small parts, which he thought were likely to become deranged. It was stated that there was less likelihood of a downward flash in the White than in the Clarkson generator. However, he had heard that Mr. Clarkson had now introduced a small steam jet to prevent that. The conical shaped coils were a great advance in generator design, but he thought that it was probable that air locks might form in it, and asked if trouble had been experienced from this source.

Mr. Druitt Halpin did not agree with one of the previous speakers, who had said that mushroom valves worked loose, neither was he of opinion that they knocked themselves to pieces. Anything would do so, he said, if not properly designed. He reminded the members how ridges used to be formed on guide bars in old engines, due to wear, and how this was overcome by making the guide blocks slightly overrun the guide bars. So in the case of mushroom valves, the seat should be narrower than the valve face. He asked for further particulars with regard to the condensers, as the data given was insufficient to form an opinion of their working. He strongly objected to the kind of fan employed by the author, as it was a most inefficient type. He criticised the practice of following locomotive and traction engine design, and expressed the opinion that until the driving was put forward on to the front wheels side-skidding would not be overcome.

The last speaker, Mr. Henwood, referred to a motor car built by him forty years ago, in which he used a Perkins engine and boiler. He was convinced that the most important factor in connection with road locomotion was the wheels. Mr. Henwood then went on to describe a device which he considered overcame the much discussed problem of side-skidding. The meeting then adjourned until December 14th, when the discussion will be resumed and concluded.

SIGNALLING AT NEWCASTLE-ON-TYNE.

OF recent years considerable advance has been made in the operation of points and signals by power instead of the old mechanical manipulation. The advantages of the newer method are many, and amongst these may be noted the less space required for signal-boxes; the closer concentration of the levers in the locking frame; the greater amount of work that can be performed by one lever; a modification of the Board of Trade requirements as to facing points; the more accurate guarantee that points and signals have obeyed their respective levers and that the points are "home" and the signals "on"; there are no point rods and signal wires for shunters, &c., to fall over; quicker operation is obtained, and there is considerably less labour demanded of the signalman.

The smaller size of the signal-boxes is brought about by the fact that instead of the levers in the locking frame being 5in. or 6in. apart as in mechanically-operated boxes, they are only 2in. or so apart. This allows for smaller frames, and, consequently, signal-boxes. This often proves an advantage, as the area for the position of a signal-cabin is somewhat restricted, as it must be placed in the centre of its work, where the points are within the required range, and where the signalman has a view of the lines he controls. Therefore, and particularly in large yards, it is much easier to find the required space for a small box than for a large one. Further, in a power-operated plant there are no rods or signal wires to be "led away" from the box, but generally only electric wires, and as these can be carried by any route, and not necessarily by the most direct, it follows that a power operated box may be placed in positions that are impracticable for mechanically-operated cabins.

The size of the frame is further reduced by the greater amount of work that can be performed by one lever. For instance, facing point locks can be coupled to the same lever that operates the points, instead of requiring a separate lever, as is generally customary in mechanical signalling. By the adoption of "selection" one lever can actuate one of two, three, four, or more conflicting signals, as shall be determined by the position of the points. It should, however, be noted that the use of "selectors" means the introduction of special interlocking and extra apparatus to be maintained, which it is perhaps not worth putting in simply to save levers.

At the present time the Board of Trade limit the distance facing points may be from the lever operating them to 220 yards; but in the case of power-worked facing points they to secure that a signal goes to danger. It will thus be seen that should a lever not be freed by the return indication, the signalman would be advised that it had not done its work, and would take the necessary action. Further, as the lever could not complete its stroke, the interlocking that would come into play when the lever was fully over or normal would not be freed, and, therefore, conflicting or sympathetic levers could not be moved. This arrangement also guarantees that the points are in position, and corresponding to the signal, and secures the "detection" called for in modern signalling.

The use of track circuits has greatly increased the benefits of power signalling. Where these are employed the line is

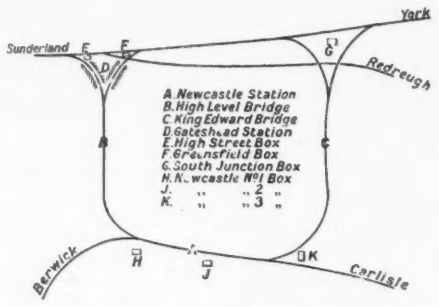


Fig. 1—RAILWAYS AT NEWCASTLE

divided into sections. The rails in a section are bonded together by a light wire, and each section is isolated from the adjoining section by an insulated joint instead of the usual fish-plate. When the track circuit is employed for the purpose of preventing a signal from being lowered if the section be obstructed, the lever operating the signal is provided with a lock actuated by a relay. This relay is placed at the near end of the section, and the battery operating it, known as the track battery, at the far end of the section, and the current normally flows through the bonded rails. If, however, a train, or any portion of a train, is in the section the wheels short-circuit the current and the relay would be de-energised, at Tyne Dock and the other at Paragon Station, Hull—which works were carried out by McKenzie and Holland, Limited, of Worcester, to whom the contract for Newcastle was also let.

In the Westinghouse system air under a pressure of from 65 lb. to 70 lb. per square inch is employed as the motive power for both points and signals. It is conveyed from the air compressors in a power-house in an air main, about 2in. in diameter, from which smaller branches lead to every point and signal. Air is admitted to the motors through valves, opened and closed by electrical relays operated by currents set up in the locking frame by the movements of the various levers, so that when a point has to be moved the signalman pulls forward the lever. He can only draw it forward halfway, as, when in the mid-position, a lock enters the lever and stops its further progress. It has, however, travelled sufficiently to set up the requisite circuit for actuating the relay on the point motor. This admits air to a cylinder, to the piston of which is attached a rod coupled—in the case of facing points—to the usual locking bar. The first movement raises this bar, which cannot be done should a vehicle be on the bar, and, therefore, if anything is on the points the movement is suspended. If the bar be free it is raised and this withdraws the plunger that locks the points, as the plunger is attached to the bar. By the time this movement is complete a pin on the rod comes into contact with an alligator-jaw crank, thereby moving over the switches which are coupled to the crank. That done, the alligator jaw is free of the pin, but the rod, bar, and plunger continue moving, and the latter bolts the switches in their new position. The last part of the stroke moves over an electric switch in an indication-box near the points, and the switch causes contacts to be made that send a current to the locking-frame—which is the "return indication" already referred to—that takes out the lock on the lever and allows it to be pulled fully over. All the mechanism at the points is moved as in a chain, so that the failure of any one part prevents the return indication being given.

Trailing points are coupled direct to the motor, but the indication contact rod is attached to the opposite point switch to that connected to the motor.

Signals are operated somewhat similarly, except that no power is required to return the signal to danger, as this is effected by its own gravity, and the "return indication" is given when the arm assumes the horizontal, and this allows the signal lever in the locking frame to be put fully back. It should here be remarked that the pause in pulling over

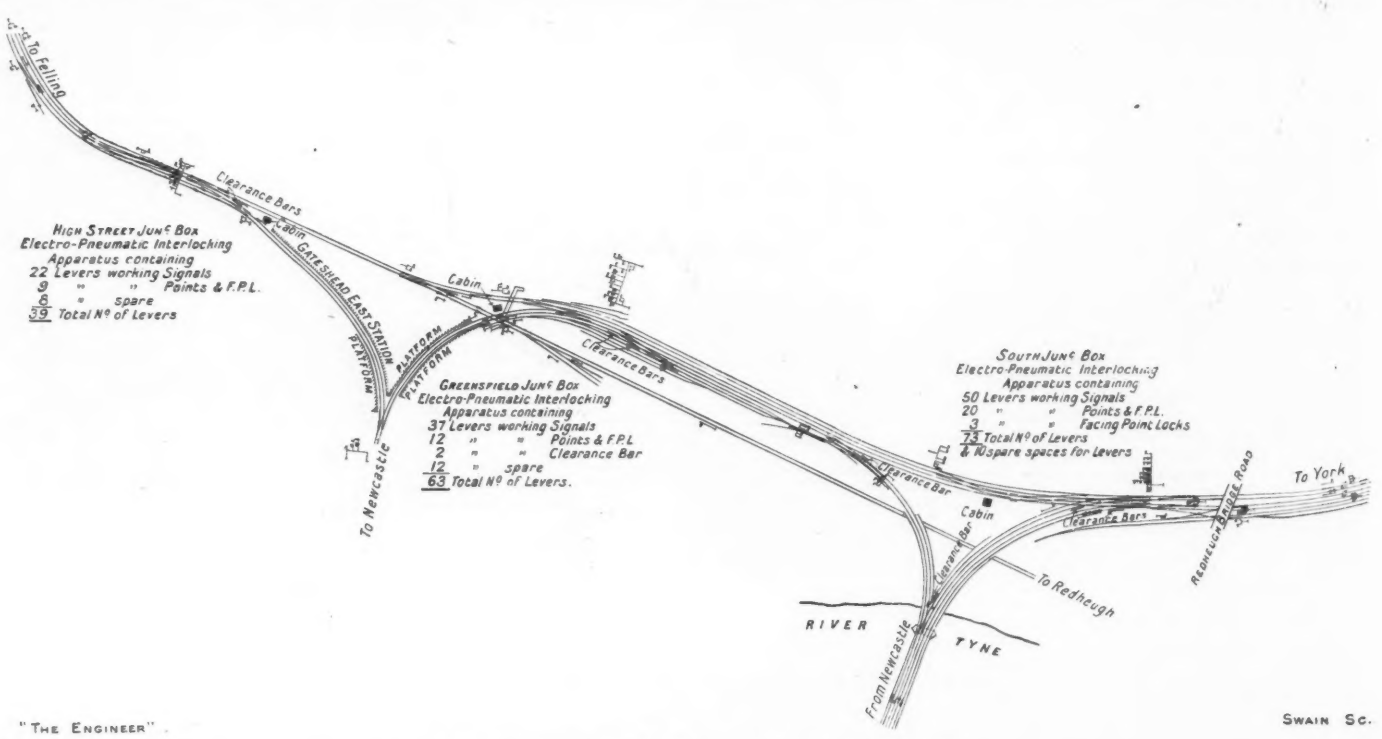


Fig. 2—LINES AND SIGNALS SOUTH OF THE TYNE AT NEWCASTLE

have agreed to modify their requirements, and allow them to be 300 yards from the lever, providing the view of the line is satisfactory. This concession has at least four advantages. It allows points to be further from a signal-box, and it permits greater freedom as to the site for the box. And, what is often a great boon, it allows the engineer to plan the lay-out of a station or a yard to greater advantage when he is not so tied down to get the points within a certain range.

But the greatest boon of this concession is the economy that can be effected in the number of signal-boxes, as, with a power plant, one cabin can do the work that would, under the Board of Trade conditions as to the maximum distance for facing points, require two signal-boxes. What this means may be judged from the fact that on Cromwell curve on the District Railway one power-operated box does the work that previously required three mechanical cabins.

The more accurate guarantee as to the position of points and signals operated by power is obtained by what is known as the "return indication." In the system now about to be described—that at Newcastle-on-Tyne, and in most others—the full movement of the lever is checked midway, and cannot be completed until the point or signal movement has been completed. The first part of the stroke sets up the electrical circuit that causes power to operate the motor working the points, and when the switches are fully over—and bolted in the case of facing points—an electrical contact is made which completes a circuit that withdraws a lock in the stroke of the lever, and allows it to be pulled—or pushed—fully over. In the case of signals, this is only done when the lever is being returned to normal to put the signal to danger, as it is not considered necessary to ensure that a signal comes "off," as no harm, only possible delay, can result from a failure to do this, whereas it is essential so that the lock on the lever is not withdrawn and the signal cannot therefore be lowered. Track circuits also restore signals to danger automatically, and independently of the signalman, when a train runs into a section, or should the section be obstructed from any reason—a broken rail will short-circuit the current—and the signalman, when a signal has been restored automatically, must subsequently put his lever to normal before the signal can be again pulled off.

A further safeguard is obtained from the use of track circuits, which is to hold conflicting point levers when a line is occupied, or when a train, or any part of a train, is standing in a position that is dangerous to trains that have to pass over other lines. Under those conditions the levers working the points or signals that give access to the obstructed track are held by the use of a track circuit laid down over the part where the obstruction would stand. They are also used to prevent levers actuating signals being put fully back until the train has passed over the points and crossings protected by the signal. This is technically known as "holding the road." The signalman can put the lever sufficiently far back in the frame to cause the signal to be restored, but not fully back, and as, of course, until the lever is fully reversed, the interlocking remains in conflicting point and signal levers, the latter cannot be moved and the road is held intact. After the train has passed over the junctions and crossings the track circuit is restored and the signal lever can be put fully back.

From the foregoing recital of the advantages of power signalling it will be readily understood why the North-Eastern Company decided to adopt such a method of operation for the additional signalling at Newcastle. The system employed is the Westinghouse electro-pneumatic, of which the railway company had already had some experience, as they have two large installations already on their line—one or restoring a lever is only momentary, as the "return indication" should come in within two seconds.

The Westinghouse locking-frame is a very compact machine. The levers are miniature ones, 2½in. apart, and are carried in a wooden case 4ft. high and 4ft. wide. The usual tappet locking is employed. It is carried vertically on the front of the frame and behind glass doors of the wooden case. Incidentally, it may be observed that at Newcastle No. 3 box part of the locking has to be carried under the floor of the signal cabin.

In Fig. 1 is a key plan of Newcastle. There are six signal-boxes, and of these five are included in the present work, the other—Newcastle No. 1—remaining for the present a mechanically-operated box. This cabin is well known to railway men, and contains one of the largest locking-frames—244 levers—in this country. Its reconstruction is postponed owing to probable re-arrangement of that end of the yard.

In Fig 2 is a diagram of the lines, signal-boxes, and signals on the south side of the Tyne. There are three signal cabins—South Junction, Greensfield Junction, and High-street. The South Junction contains eighty-three levers, of which ten are spare. It controls the triangle leading from the old main line to King Edward's Bridge. It will be noticed that "clearance bars" are provided in certain positions. These are operated by independent levers, which precede, in the interlocking, the levers working the signals that should be kept at danger if the tail of a train be standing foul. In such an event the bar could not be raised, and therefore the signals could not be lowered. Greensfield Junction contains sixty-three levers, of which twelve are spare. It controls Gateshead Station and the roads between the old main line and the High Level Bridge. High-street box contains thirty-nine levers, of which eight are spare.

In Fig. 3 is a diagram of the lines, signal-boxes and signals

at the north end of King Edward's Bridge, on the Carlisle lines, and in the greater part of the station. The position of No. 1 box is shown, but as this is to be re-signalled later, no reference is made to it here. No. 2 box contains sixty-seven levers, of which twelve are spare.

The signalling of No. 3 box is the most important part of the work, and we therefore propose to deal with it in some detail. The box contains 211 levers, of which fourteen are spare. The number of levers might have been very much greater had the railway company been so disposed. On reference to the diagram it will be seen that only one number is placed against many signals which have two arms. For instance, on signal bridge B nearly all the posts carry two signal arms. The upper of these are stop signals of the usual type and purpose, and the lower, shorter, arms are "calling-on" signals. By the use of "calling-on" signals drivers are advised to proceed, but that the line ahead is obstructed, and that they are to exercise care and be prepared to stop clear of the obstruction. The upper arms indicate a clear section. Both arms are operated by one lever, the first part of the stroke lowering the "calling-on" signal, and the remainder of the stroke pulling off the upper arm. A notch is provided in the centre of the lever quadrant to hold the lever midway. In this respect alone there is a great saving in levers, and not only that, but in interlocking and in the signalmen's movements.

A further saving has been effected by the use of "selection," whereby one lever is allocated to two signals, but only one arm will respond, and this the one that is applicable to the position of the points. Such a case is seen in the lower right-hand corner of the diagram of No. 3 box. Two signals are shown to be actuated by lever No 193, the left-hand arm being for leading along the straight line with No. 172 points normal. The other arm is for leading from the siding on to the up passenger line with No. 172 points over. The signal is provided with two motors in the usual way, which are in conjunction with a "selector" coupled to the points, so that when the signal lever is pulled in the cabin, air is admitted to that motor which corresponds with the position of the points.

be operated by levers in the locking frame. No effort has been spared to provide for every possible movement, and the order of the levers has been schemed so as to concentrate the work as much as possible.

The power-house is situated in the arches under the railway at the east end of the station and near the old High-Level Bridge.

The compressed air is obtained from a compressor, capable of compressing 120 cubic feet of free air to six atmospheres per minute, driven by a 30 brake horse-power gas engine, to which it is direct coupled. There are also a duplicate engine and compressor fixed as a reserve. The engines and compressors work on an average about eight hours a day, being stopped when the pressure reaches 90 lb. per square inch, and re-started when it falls to 50 lb., at which pressure an automatic whistle blows to give warning. The power plant for generating the necessary current for the electric control consists of two National gas engines, each direct coupled to a shunt wound dynamo having an output of 1·8 kilowatts, one engine and dynamo being used at a time, the other acting as a stand-by. There is also a reserve motor generator, having an output of 1·8 kilowatts, the motor being driven from the 480 V. continuous-current main.

The accumulator cells from which the installation is worked are arranged in two batteries, so that the one can run the installation while the other is being charged.

The controlling switchboard is arranged to carry all switches for batteries, dynamos, and starting gear for the motors. The electric currents for actuating the valves of point and signal-motors are conducted from the controlling contacts in signal cabin by leads made up into core cables, each cable having the requisite number of conductors for the points or signal which it controls. All cables are run in prepared wood casing, which is filled in with an elastic pitch compound.

There are four air receivers, each with a capacity of 120 cubic feet, fixed in suitable situations to carry a reserve of compressed air, also a small auxiliary air reservoir fixed at each set of points, &c.

There will be a total of 401 working and 62 spare levers, and spaces provided for future extensions, and these will operate

ness on this subject, because on several of the mines where the Chinaman is installed, a proportion of the unskilled labour is native.

The labourers at work in the mines exceeded in numbers those employed in the previous month by nearly 3000, there being a gain from two sources. A new shipment of coolies brought the number of Chinese up to 53,400 from 52,083, while the net gain in the number of natives in the books of the Witwatersrand Native Labour Association amounted to 1612. The retirement of the Robinson Group of mines from the Witwatersrand Native Labour Association was announced last week. The step was expected, as relations had become very strained. It is regarded locally with satisfaction, as it leaves the management of the retiring group now perfectly free to obtain all the labour it possibly can from those places where for some time past it has urged a sufficiency can be obtained provided the methods adopted are the right ones. Whether the promised unskilled white labour experiment will be tried is not definitely known, but Johannesburg does not appear to regard it seriously as a possibility.

The operations of the Premier Diamond Company for the month of September were markedly successful. The declared output of diamonds was 106,212 carats from 338,154 loads washed—that is, 0·31 carats per load. This is the best yield since March last, and is 20 per cent. better than that achieved during the months of July and August.

The trials of the direct dry treatment of hard diamondiferous ground by means of tube mill and induced draught, which were previously alluded to in these columns as having taken place at the Montrose Diamond Mine, have been sufficiently successful to lead to tests on a more extended scale. A contract has now been entered into by the syndicate representing the inventor to treat 40,000 loads of floored blue ground at the Montrose Mine. This extended trial, of a real and practical nature, should bring to light the true value of the new process.

At the meeting of the South African Association of Engineers held on 6th October a paper was presented dealing with that most important subject, "Sewerage and Storm-water Drainage in Johannesburg." The authors were Mr.

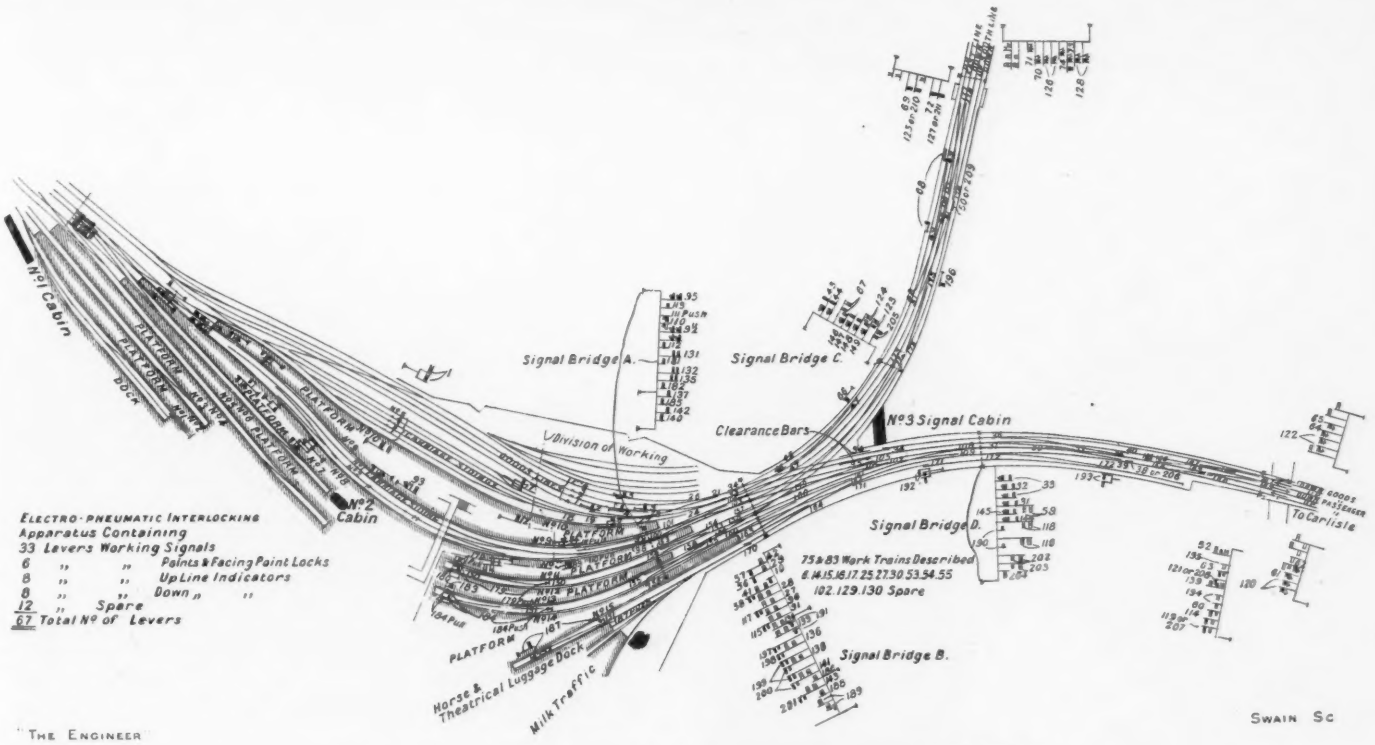


Fig. 3—LINES AND SIGNALS, NORTH END OF KING EDWARD'S BRIDGE, NEWCASTLE

Where two distant signals are shown as coupled to one lever, *e.g.*, those on Nos. 120 and 122 in the extreme right-hand corner, these are "selected" by the home signals they apply to. Take No. 120 for an example. These two distants apply to the inner home signals Nos. 116; 118 on signal bridge D. Should No. 116 be lowered, then the left-hand arm of the two signals would fall, after, of course, the outer home signal No. 119 had been lowered.

It will be noticed that this arm can be lowered by either No. 119 or No. 207. This is owing to a wise arrangement whereby the signalman's work is very much reduced. Let us imagine, for instance, a train from Carlisle on the up passenger line, and which has to run into one of the dock lines on the lower left-hand side. This would require one of the three inner home signals Nos. 202, 203, or 204 on signal bridge D. By coupling the outer home to No. 207, as well as to No. 119, there is less work for the signalman. But if the train is to run on the main line, which requires either signal No. 116 or 118, then No. 119 is most convenient for working the outer home signal It also allows for different signalmen to deal with certain roads without overlapping. Some of the facing point locks are operated similarly, as, for example, No. 38 or No. 206 for No. 39 points. The two clearance bars near the signal-box are not, as at the other cabins, operated by separate levers, but are coupled to the points, so that the road cannot be disturbed until the train has gone clear.

Track circuits referred to are to be employed at Newcastle, so as to control the signalmen's movements, and prevent signals being lowered unless the line ahead is clear. It is also proposed to provide an illuminated diagram whereby visual indication is given to the signalmen whether a line be free or occupied. This is done by providing behind an opal glass, upon which the lines are marked, incandescent bulbs, which are alight as long as the line or siding is clear, but when it is blocked, the lights, by means of the track circuit, are switched out.

Train describers—one for each line—indicating the title of an approaching train, are also to be provided, and these will

352 signals, 108 trailing points, 67 facing points, 11 facing point locks, 8 clearance bars, 9 train describers, and 16 indicators.

No. 3 box and that at the South Junction were partly brought into use when King Edward's Bridge was opened, and the other three boxes are nearing completion, and will be brought into use at an early date.

We are indebted to Mr. Chas. A. Harrison, the chief engineer for the Northern Division, North-Eastern Railway, Messrs. McKenzie and Holland, and the Westinghouse Brake Company for assistance received in the preparation of this article.

NOTES FROM SOUTH AFRICA.

(*From our own Correspondent.*)

JOHANNESBURG, October 22nd.

THE monthly declaration of the Transvaal Chamber of Mines showed that the total gold output was 505,111 oz., of value £2,145,575. This amount, although 4004 oz. below that produced during the month of August, is still very satisfactory, and indicative of a record daily rate of production. The average yield per "milling" day during August was 16,423 oz., while that during September was 16,837 oz. If averaged per "mining" day, these figures become 18,856 oz. and 20,204 oz. respectively. It may be stated that, in the Transvaal, the reduction and treatment processes proceed continuously, except for breakdowns, while the mining and hauling work is disallowed on Sundays, Christmas Day, and Good Friday. In the month of September there were eighteen mines that each produced over 10,000 oz. of gold, the leader being the Simmer and Jack Mine, with an output of 22,853 oz. The total number of stamps at work in the Transvaal was 8315, this being an increase of 60. About 40 per cent. of these stamps were fed with ore mined by Chinese workers, and this much attacked class of labour was responsible for approximately the same percentage of the gold output. It is not possible to speak with absolute exact-

D. C. Leitch, late town engineer and now chief engineer of the Rand Water Board, and Mr. S. L. Burt Andrews, the present town engineer. The paper consisted of a brief review of the principal features of the work now in progress on these schemes, and at the same time advantage was taken to reply to the many criticisms that have been published locally dealing with not only the design but the construction work completed up to date. With respect to the plans decided upon, the two chief objects of attack have been (1) the practice of laying the storm-water drain and the sanitary sewer in one and the same trench, the latter underneath the former; (2) the decision to adopt bacterial treatment of the sewage, and to establish an irrigation farm at Klipspruit, some nine miles distant from Johannesburg, as against the alternative of bacterial treatment in the immediate vicinity of the town, and then allowing the effluent to run to waste, or else to sell it subsequently to the mines for industrial use. There is likely to be considerable discussion on this paper, and the *pros* and *cons* may more suitably be treated in a separate article at a later date.

There occurred on the evening of Friday last, October 19th, one of the worst accidents that has ever taken place in connection with these mining fields. At the "Lohse" vertical shaft of the Simmer and Jack East Gold Mining Company the night shift of workmen was being sent below. At about 6 p.m. a double-decked cage containing twenty-three Chinamen was being lowered down the shaft; a depth of 750ft. had been reached when the rope suddenly parted, and the cage and its human freight were dashed 1200ft. into the sump at the bottom of the shaft. Needless to say, instant death and terrible mutilation was the fate of all the passengers. The winding engine was a geared engine, with two high-pressure cylinders of 13in. diameter and 26in. stroke. There is a pair of winding drums of 6ft. diameter and 24in. wide, each with a clutch. Both drums were being operated at the time of the accident, the right-hand drum raising the empty cage, while the left-hand drum, in which the rope was "overwound," was lowering the cage full of coolies—just one passenger short of the licensed complement of twenty-four.

The speed of lowering was about 800ft. per minute, and when the indicator showed a depth of between 700ft and 800ft. the driver suddenly noticed the rope on the left-hand drum fracture, the broken end going out of the engine-room, up to the head-gear, and then down the shaft. With great promptitude he brought the engine to rest, and immediately reported the occurrence. Examination showed that the rope had been broken owing to its fouling the countersunk head of one of the twelve bolts that secure the spur-driving ring to the flange of the drum. This bolt was check-nutted, but both nuts must have slacked back about 1¼in., and the bolt must have more or less suddenly jumped back the whole of the clearance thus provided. There were no marks of long chafing or rubbing on the countersunk head of the bolt, but simply one deep impression of the wires of the rope at one spot on the V-shaped circumference of the head. The 1¼in. bolt was also severely bent at a spot which clearly showed to what extent it had come inside the flange. The 1in. diameter rope, it may be said, was of best plough steel, put on last March, and not at all badly worn. It was severed by a clean cut. The records of the statutory examinations showed that the loosening of these bolts is not at all a usual occurrence, but it will now be deemed necessary effectually to prevent this possibility on this class of winding engine, of which there are a large number in use on the Witwatersrand. Once again has it been proved here that a sound winding rope does not necessarily secure safety to persons. The safety catches in this instance were of the old-fashioned toothed excentric type—lever coupled to the king bolt of the cage. This type of safety catch has been known to be useless when the rope breaks at the drum end. It will now—too late, of course—be changed for one of those designs which have been proved to be successful in action on wooden guides even under the most unfavourable conditions.

GEAR CUTTING MACHINES.

THE gearing of the Laval steam turbine consists, as our readers are well aware, of very high ratio spiral or helical gears, which, in order to be efficient and silent at the enormous speed of rotation of the driving pinion, must be cut with great accuracy. A couple of machines used for this purpose, and, of course, suitable for any similar work, are illustrated by four views on page 578. The machines are made by Greenwood and Batley, of Leeds. That illustrated by Figs. 3 and 4 is arranged to cut wheels up to 24in. diameter, and is belt driven. The wheel to be cut is mounted upon a mandril, one end of which is firmly connected to the driving spindle, whilst the opposite end is supported by an ordinary sliding spindle with screw adjustment.

A milling cutter is used. The cutter spindle is mounted in a swivelling head, adjustable in a vertical plane for the angle of the spiral, and carried on a cross-slide fitted to a sliding carriage, having a variable self-acting slow feed motion and quick return driven from the two-speed cone pulley placed at the end of the bed, and connected to the screw by gearing —see Fig. 3. The cutter is driven by an independent belt and bevel gearing, and knock-out motion for its feed is provided.

The driving or work spindle is fitted with the usual hand-dividing apparatus, and also with rotating gear, consisting of a worm wheel attached to a sleeve, which also carries on a disc the dividing plate, worm, &c. The weight of these parts is counterbalanced by a piece cast on the disc, as seen in Fig. 4. As the whole of the dividing mechanism revolves with the work, the accuracy of the dividing is never in doubt. The screw which controls the self-acting feed motion to the sliding carriage and cutter head is connected by change wheels—see Fig. 3—to the worm shaft driving the rotating motion. It will be clear without further explanation that if motion is given to the sliding carriage through the screw the driving spindle will be rotated in accord with the gearing which connects the worm wheel and the screw, and a proper spiral cut will result.

The other machine shown by two views on page 576 will cut spiral wheels up to 3ft. 10in. diameter. Its construction is very similar to that of the machine illustrated above—Fig. 2—which, however, takes a wheel of a maximum size of 24in. Each machine consists of two beds placed parallel to each other on one base plate. The one bed carries the sliding carriage, with the cutter spindle mounted on a swivel slide with a hand-cross adjustment by screw. The cutter spindle and traverse screw are connected to the electric motor —seen best at the end of the bed in Fig. 6—by gearing, which gives a constant slow cutting speed and a quick return to the sliding carriage. An automatic stop motion in both directions is provided. The cutter spindle is driven also by the same motor through bevel and spiral gearing, which renders it possible to adjust it to any angle required.

Mounted on the second bed is the dividing spindle, with its division plate and rotating gear, which is connected to the traverse screw in the first bed by change wheels, the plate for which can be seen in Fig. 5. The dividing spindle is fitted with a chuck for the end of the mandril on which the work is carried. The opposite end of this mandril is supported in a bushed stay. Mounted on the dividing spindle is a sleeve fitted with a worm wheel for the rotating motion at the one end and with a balanced arm carrying the locking bolt for the division plate at the other.

The second bed has a screw adjustment on the base-plate to enable the beds to be adjusted to the proper distance apart to suit the various diameters of wheels which may require to be dealt with.

Finally we illustrate—Fig. 1—a machine arranged to cut spiral wheels up to 12in. diameter, and driven by one electric motor placed above the main frame. This machine consists of two principal parts—viz., a horizontal bed and a vertical upright of box section. Mounted on the bed is a travelling carriage, fitted with a dividing spindle and a chuck for securing and holding the mandril on which the work is mounted. On this dividing spindle is fitted a socket which carries the worm wheel for giving rotary motion to the spindle, and a balanced arm carrying the locking-bolt for the division plate. The outer end of the mandril is supported by the usual poppet or loose head. The rotating gear is connected by change wheels to the traverse screw controlling the sliding carriage by change wheels. The cutter spindle is driven by bevel wheels direct from the electric motor. This spindle is mounted in a swivel slide carried by a balanced vertical slide having a vertical screw adjustment.

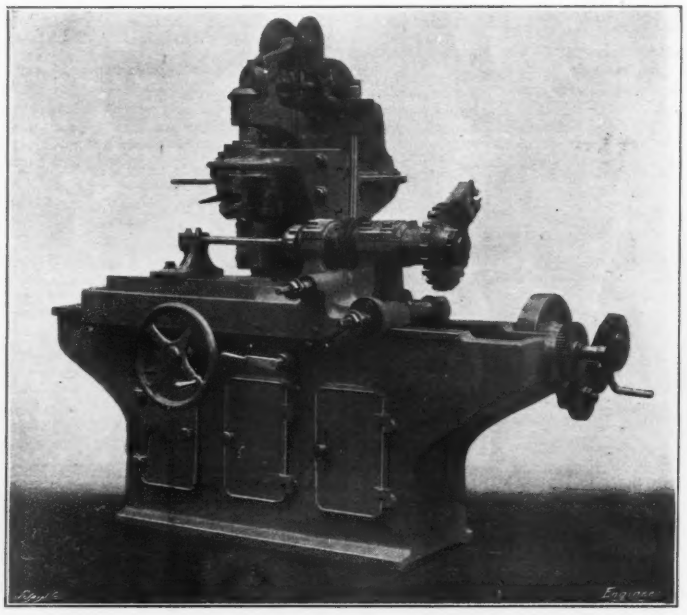


Fig. 1—12-INCH SPIRAL GEAR CUTTER

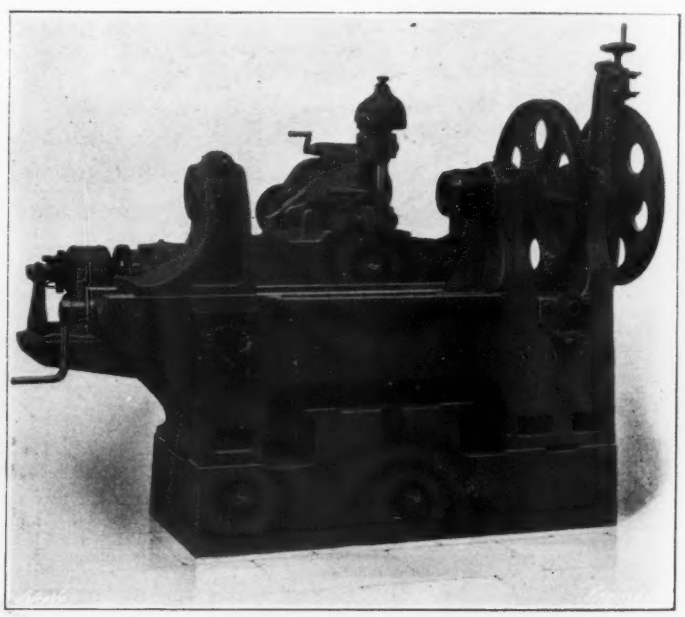


Fig. 2—24-INCH SPIRAL GEAR CUTTER

DOCKYARD NOTES.

GERMAN coaling records—getting coal in anyhow and any way—are:—Elsass, average 351 tons per hour; K. Wilhelm II., 339 tons; Roon, 336 tons; Arcona, 189 tons. These results are half as good again as any of the records of our own Navy. The explanation is to be found in the fact that coaling ships in the British Navy is now an evolution for which there are the proper "rules of the game." The Germans apparently have no rules of the game beyond the conception that a ship, coming into harbour in war time, wants to get its coal on board "anyhow and any way" in the minimum time. It appears to have been merely a matter of shipping sacks. We might well copy it, even at the risk of losing a favourite evolution. Evolution coaling in Germany is behind ours, the best records being:—Zaehrungen, average 172 tons per hour (two colliers); Preussen, 97 tons (one collier); Friedrich Carl, 125 tons (two colliers); Ariadne, 58 tons (1 collier). We can undoubtedly do better than that.

THE new Austrian battleships are now practically decided on. They are to be of 14,500 tons, 20 knot speed, armament four 12in. and eight 9·4in. They will somewhat resemble the Lord Nelson.

THE coming expansion of South American navies attracts very little attention. Peru has launched her second fast cruiser at Barrow—the Colonel Bolognesi; Brazil has three battleships in hand at Elswick; Argentina is contemplating three; so also is Chili. Even Mexico has a programme.

THE Spanish cruiser Reina Regente has been launched. She was laid down shortly before the war with the United States, and will be completed probably by 1912.

THE Italian submarines of the Glauco class are now nearly completed. Seven boats of a new type are to be built. The first is known as the F.I.A.T. Muggiano and is of 220 tons. Surface speed, with F.I.A.T. motor, 15 knots; radius, 175 miles and 600 miles at 10 knots; submersion time, 5 min.; armament, two 18in. tubes. Two periscopes will be fitted.

Two of the C class submarines have now been delivered. They are larger than the B's, but do not greatly differ from them in appearance.

CUXHAVEN and Sonderberg are being made into naval ports in Germany.

ON her low-power trials the French cruiser Victor Hugo, with 7000 horse-power, realised 16·2 knots.

SWEDEN has just ordered two more destroyers of the Mode type.

INVITATIONS to tender for the construction of the machinery for the two new battleships of the Dreadnought type to be laid down in the dockyards have been sent to no fewer than seventeen firms throughout the kingdom, six of whom are on the Clyde. Heavy penalties are to be exacted for late delivery of the machinery for these vessels, as also for delay in the completion of the hulls, to be built in a private yard, the amount being £100 per day beyond the two years. In the case of the two dockyard ships the machinery is to be completed by October, 1908, and for excess of weight in the machinery for all three ships a penalty also is to be imposed.

THE YORKSHIRE COKE TRADE.

DISCUSSING the coke trade recently, we remarked that the production of coke in connection with the working of collieries is becoming of vital importance, inasmuch as in many instances a large portion of the profits made is traceable to the production of coke under the various by-product systems. An announcement has been made during the week which is likely to play an important part in connection with the Yorkshire coke trade. The Crigglestone Collieries, near Wakefield, after having been laid idle for about a year, have just changed hands. It is stated that the colliery produces a good brand of coking slack and smudge, and it is understood that some of the thinner seams will be worked—doubtless, with a view of feeding the battery of new Otto coke ovens which it is intended to erect as soon as possible. The opening out of the colliery is looked forward to with great interest by all interested in the coke trade. It may be stated that up to the close of last year there were Otto 170 ovens at work in Yorkshire, and 251 in Durham, and these numbers have since been augmented. It may not be without interest to note that for the first time last year a return was included in mineral statistics relating to the production of coke; Durham ranks first and Yorkshire second as regards the production of this material. In 1905 5,312,848 tons of coal were consumed by Yorkshire ovens in the manufacture of coke, the year's output of the county being 2,896,544 tons. The Yorkshire coke trade at the present time is unusually active, and North of England coke being dear and not over-plentiful, South Yorkshire producers are able to compete successfully in the North Lincolnshire and other large iron smelting districts. Next year's contracts are being placed at 9d. to 1s. per ton advance, and during the week there have been inquiries for immediate supplies for South Yorkshire coke for furnaces and ironworks in the Middlesbrough district.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—A meeting will be held at St. Bride's Institute on Wednesday, December 12th, at 8 p.m., when Mr. H. C. H. Shenton, M.S.E., will read a paper on "Small Water Supplies." The second discussion evening of this session will take place at the Institute, on Saturday, December 15th, at 7.30 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—A meeting will be held on Saturday, the 8th inst., when the third paper of the session 1906-7 will be given by Prof. W. H. Watkinson, M. Inst. C.E., on "Steam Turbines as applied to Steamships." The chair will be taken at 7 p.m. by Mr Wm. Rhodes, of Haworth. On Monday evening, December 17th, 1906, a discussion meeting will be held in the rooms of the Association, at 7.15 p.m., when a short paper will be given by Mr. Chas. H. Dewhirst (chairman of the Council), subject "Gear Boxes for Motor Cars," when the Council hope to have a good attendance of members, so that there may be an interesting discussion.

CANADIAN TRADE INDEX.—The Secretary for the High Commissioner for Canada has sent us a copy of a volume entitled "Canadian Trade Index," which has been compiled for the Canadian Manufacturers' Association. In addition to containing a classified membership directory of the above Association, the book possesses many other features which go to make it almost indispensable to everyone engaged in export business with our Colonies. There is statistical information, which is very complete; a map of Canada, in colours, which is legible; a list of the steamship lines; and indexes, in English, French, and Spanish, of the articles made by the members, who number over 2000. It should be stated that the objects of the Association are to promote Canadian industries and to further the interests of Canadian manufacturers and exporters. Copies may be had of the High Commissioner of Canada, 17, Victoria-street, S.W.

RAILWAY MATTERS.

THE Boston and Maine Railroad has contracted for the material for automatic block signals on 1000 miles of line.

THE New York Central Railway has granted an increase in wages to its firemen and engineers, and to the latter also a ten-hour day.

THE quantity of coal consumed for locomotive purposes by the railway companies in the United Kingdom was 11,593,758 tons in 1905, as against 11,455,364 tons in 1904, and 11,399,413 tons in 1903.

ACCORDING to details of the railway estimates of Switzerland for 1907, the total expenditure under the heading of construction during that year is fixed at about £1,850,962, as compared with £1,588,991 this year.

THE Grand Trunk Railway Company intends experimenting with a smoke-consuming device on its switch engines. If the results are satisfactory, all the Grand Trunk engines will be equipped with smoke consumers.

THE Tehuantepec National Railway Company's road across the isthmus of Tehuantepec, extending from Coatzacoalcos on the Gulf of Mexico to Salina Cruz on the Pacific Ocean, about 200 miles, was opened on 1st November.

THE first section of the Nagda-Muttra railway line, from Nagda to Morak, a distance of 101 miles, will be ready for opening to traffic in January next; and the second section, from Morak to Kotah Junction, a distance of 37 miles, in April next.

THE Pennsylvania Railroad is constructing six tubes—two under the Hudson River to the west of New York City, and four under the East River. This is only one of five separate undertakings to provide communication between the three cities of New York, Jersey, and Long Island.

THE *Bollettino delle Finanze* states that Signor Schupfer, the Director of Erythrean Railways, has been in Rome for some time past with a view to discussing the question of railway construction in Erythrea. It is added that the Minister of Public Works will shortly invite tenders for the construction of a line between Ghinda and Nefasit.

AT the close of 1903 there were in India 14,477 miles of standard, or 5ft. 6in. gauge; 11,421 miles of meter, or 3ft. 3¾in. gauge; 796 miles of 2ft. 6in. gauge, and 262 miles of 2ft. gauge, open to public traffic, making a total of 26,956 miles; while 1162, 1273, 575 and 113 miles, respectively, were under construction and sanctioned.

A SCHEME for railway electrification has been suggested to the Isle of Wight County Council. In a report to the Council the Parliamentary and Railway Committee, who had under consideration the proposal that the Council should acquire and work the railways, urged that any scheme which would be calculated to improve the existing state of affairs, as regarded the railways, should receive every support.

THE directors of the Caledonian Railway have been compelled to make reductions in the staff of mechanics, and to shorten hours of labour in the shops, in order to meet the falling off in revenue, indications of which have appeared in the traffic returns of the last few weeks. The industrial depression which has caused this contraction in business is chiefly attributable to the recent boilermakers' strike.

AT a special meeting of the shareholders of the Limavady and Dungiven Railway, held in Limavady last week, a letter was read from the Board of Works stating that the line had never paid its debt, amounting to almost £29,000 The Board was, however, unwilling to contemplate the abandonment of the line and the sale of the material, and at considerable sacrifice they had agreed to sell the undertaking to the Midland Railway Company for £2000.

THE Caledonian Railway Company has decided upon the installation of electro-pneumatic power for operating the signals and the points at the Glasgow Central Station. The whole of the traffic will be worked from one cabin fitted with no fewer than 347 levers. The Westinghouse electric-pneumatic signals will be used, and the instal ation, which is to be carried out by McKenzie and Holland, Limited, Worcester, will rank as the largest inter-locking signalling plant ever erected.

THE twelve millions or so of extraordinary credit which the Italian Government propose spending on fortifications and armaments pale before the cost of the projects which have been elaborated for the State railways. It is stated that on the Chambers re-assembling, the Minister of Railways will present a demand for £20,000,000—all of it to be devoted to extension and renewal of lines and buildings, and none on rolling stock, which will have to be dealt with in a special credit.

THE Great Northern Company will, commencing Saturday next, issue cheap Saturday-to-Monday tickets from King's Cross to any purely Great Northern station, also between any pair of purely Great Northern stations. This concession will enable the public to gratify a long-felt desire to be able to spend the week-end with their friends without too great a tax upon the pocket, so far as the railway journey is concerned. The Saturday-to-Monday tickets will be issued at the rate of a single fare and a-quarter for the double journey, the minimum fare being 4s. first-class and 2s. 6d. third-class.

ON Saturday, December 15th, the Great Northern, Piccadilly and Brompton Railway, which runs from Hammersmith to Finsbury Park *viâ* Piccadilly and King's Cross, will be opened for traffic. It is the longest of any yet constructed, the total length being nine miles. The following is the order of the stations:—Hammersmith, Baron's-court, Earl's-court, Gloucester-road, South Kensington, Brompton-road, Knightsbridge, Hyde Park-corner, Down-street, Dover-street, Piccadilly-circus, Leicester-square, Covent-garden, Holborn, Russell-square, King's Cross, York-road, Caledonian-road, Holloway-road, Gillespie-road, and Finsbury Park. A schedule of fares, ranging from 1d. to 4d., has been arranged.

IN a report to the Trade and Commerce Department of Canada, summarised in the *Toronto Globe*, the Canadian commercial agent in Mexico states that the Tehuantepec National Railroad will be opened for traffic on January 1st, and dwells upon the importance of the new isthmus route from the point of view of Canadian interests. There is, in his opinion, no reason why Eastern Canada should not make a bid for the Pacific coast trade of Mexico, especially in manufactured articles, while British Columbia will be in a position to send her fish and lumber to Eastern and Central Mexico and the West Indies both expeditiously and at a low freight rate.

REPRESENTATIONS have been made to the Lord Lieutenant in Council from residents of Co. Donegal urging the desirability of constructing a line of railway from Glenties to Ardara. The Irish Government has also been approached for assistance in the carrying out of the project. the cost of which has been approximately estimated at from £20,000 to £30,000. At the quarterly meeting of the Donegal County Council a letter was read from the office of the Chief Secretary, Dublin Castle, stating that the Lord Lieutenant had decided that if the County Council and the railway companies interested were prepared to make definite and substantial offers as to the sum which they would contribute to the necessary expenditure, or upon which they would guarantee payment of interest, he would be prepared to submit the matter to the Treasury.

NOTES AND MEMORANDA.

IT is said that the largest pin factory in the world is in Birmingham, its output being 37,000,000 pins daily.

STERLINE is an alloy consisting of 68·52 per cent. copper, 12·84 per cent. zinc, 17·88 per cent. steel, and 0·76 per cent. iron. It is used as an imitation silver.

THE alloys of lead, tin, and bismuth show peculiar properties. A mixture consisting of the following—bismuth 2 parts, tin 1 part, lead 1 part—melts at a temperature slightly below the boiling point of water. It also expands no cooling.

MANGANESE ore was exported from India last year to the amount of 316,694 tons, as against 180,945 tons in 1904. The rise in average value in India is only about 2·4 per cent. The exports go mainly to America, the United Kingdom, and Europe.

AN interesting property of calcium is its ability to combine with nitrogen. This property, with fixation of oxygen, can be utilised to produce chemically a vacuum in incandescent lamps or X-ray bulbs. It can also be utilised to eliminate completely the occluded gases in cast iron or molten steel.

MAGNET windings of uninsulated wire are said to have proved feasible by the use of aluminium wire, the natural oxide upon which forms an effective insulation for moderate voltages. For over 200 volts, paper wound wet between the layers is effective, and for higher potentials, extra oxidisation has been secured by dipping in a chemical bath.

THE production of copper in the United States in 1905, according to a bulletin just published by the Geological Survey, exceeded 901,000,000 lb. The three leading regions of production are Butte (Mont.), Arizona, and the Lake Superior region. In Idaho and Utah there is a marked increase, while in California and Tennessee there is a decrease, which is believed to be temporary.

THE coaling record in the Mediterranean Fleet recently made by the Implacable, battleship, has been lowered by the Bulwark, battleship, flagship of Lord Charles Beresford, which has taken in 880 tons at an average of 251·1 tons per hour. The Implacable shipped 1100 tons at an average of 236·3 tons per hour. The Bulwark coaled from three winch lighters, whereas the Implacable used two.

OF twenty-two gas installations in Germany, of a total of 13,000 horse-power, working on coke oven gas, eleven, or 50 per cent., do not find it necessary to purify the gas. The others use bog-ore or sawdust. With efficient tar extractors and ammonia washers, tar and dust are readily removed. One of these German installations was using a gas with 0·2 per cent. sulphur without injurious effect on the iron.

ACCORDING to the American Consul at Lyons, the French Government statistics concerning the output of iron and steel in France for the first six months of 1906 give the production of pig iron as 1,573,504 tons, an increase of 73 000 tons over the amount in the same period of 1905. In rolled iron and steel the production was 384,000 tons, an increase of 18,000 tons. In cast steel the production was 230,000 tons.

THERE were sixty-two works engaged in the manufacture of files in America in 1905, as compared with eighty-six in 1900. The total capital of the industry in 1905 was £1,173,251 as compared with £751,529 in 1900. The number of wage earners employed rose from 3160 to 3276, and the wages paid from £255,439 to £302,882, showing a materially higher rate of compensation. but a very small increase in the number of operatives in the industry.

THE Creusot Works have had an electric furnace in operation for several years. The Etablissements Jacob Holtzer will soon be provided with a large Keller furnace, invaluable for refining. The Hauts-fourneaux et Forges d'Allevard, the Usines de la Prax, and those of Gysinge have, for three or four years past, supplied tool steel, made by the electric furnace, of quality equal to that from the crucible. These facts were recalled at a recent meeting of the French Civil Engineers.

THE German Government placed an old torpedo boat at the disposal of an inventor for practically demonstrating that vessels' rolling can be diminished by an appliance revolving at great speed, like a top, so as to maintain its axis in a fixed position. A fly-wheel, weighing nearly half a ton, put in connection with the hull, was made to revolve at 2300 revolutions per minute by a steam turbine, and it was found that a light brake improved the effect. The rolling was reduced by 8 deg., and the waves ceased to break over the deck.

IN 1905 there were in the United States eighty-three works engaged in the manufacture of saws, compared with ninety-six in 1900. The reduction in the number is due to the general American tendency of combination. The capital in 1905 was £2,257,563, as compared with £1,701,097 in 1900. In 1905 there were 4650 wage-earners receiving £541.484 in wages, compared with 3212 wage-earners receiving £338,551 in 1900 It will be noted that the increase in wages has been much greater than that in the number of wage-earners reported, showing a higher scale throughout the industry.

THE Boston Elevated Railway Company has been trying gas engines for the past few months for dynamo driving, and the experiment has been fully justified. Only one of the stations has been in continuous operation long enough to obtain reliable figures, and this was of but 700 kilowatt rated capacity. The results working under service conditions for four months give 1·45 lb. of coal per kilowatt-hour on an engine load factor of about 74 per cent., says the *Street Railway Journal*. During a thirty days' regular test, when the plant was running sixteen hours per day on Pocahontas coal, this average fell to 1·31 lb. per kilowatt-hour. Taking these facts at their face value, they correspond in fuel economy with a steam plant giving the kilowatt-hour on about 12 lb. of steam.

THE Norddeutscher Lloyd mail steamer Kronprinzessin Cecilie, which was launched on 1st December, at Stettin, measures in length from stern to stem 706½ft.; her maximum breadth is 72ft.; the height from upper edge of keel to side of promenade deck is 52½ft.; the displacement is 27,000 tons; and the tonnage about 19,400 tons gross register. She has four four-cylinder quadruple-expansion engines, developing altogether about 45,000 indicated horse-power, and calculated to give the vessel a speed of 23½ to 24 knots. She has nineteen boilers, with a total heating surface of 107,643 square feet, and 291 men are required for attending the boiler plant alone. The consumption of coal amounts to about 700 tons per day, while the bunkers are capable of holding 5600 tons of coal.

IN an article by Mr. J. D. Pennock in the *Scientific American* on the Mond producer it is stated that 900,000 cubic feet per day of enriched gas of 18 candle-power were delivered during the year 1904 from the Semet-Solvay Company plant of forty ovens at Chester, Pa., to the local gas company, which, in turn, dealt it out to consumers for illuminating, gas engines, and fuel purposes. Gas containing a high percentage of benzine and methane, and low percentage of hydrogen, is formed during the early stages of the coking process. The gas formed in the latter part is practically devoid of benzine and ethylene, the illuminants, and high in percentage of hydrogen. As it is desirable for power purposes to have a gas of minimum hydrogen to avoid possibility of pre-ignition, gas of the quality represented by the first analysis is the best.

MISCELLANEA.

A STEEL floating target, for use at the Sandy Hook proving station, was launched at the Brooklyn Navy Yard recently. It resembles a section of a battleship, weighs 70 tons, and is made of 5in. and 6in. plates.

THE *Gaceta de Madrid* of 19th November contains a copy of a Royal Order sanctioning the expenditure of about £10,017 on port works at Muros, Province of Coruña. As these works are considered urgent, they will be included in the scheme of improvements to be carried out next year.

THE Lincoln City Council in committee have decided upon a waterworks scheme, which includes the building of a new covered reservoir on Cros o' Cliff Hill, with a capacity of six million gallons, and the construction of a water tower in Westgate. It is estimated that the scheme will cost something like £50,000.

SINCE 1893 close on £50,000 have been sent from Scotland for the objects of the National Lifeboat Fund, £16,500 of which have been raised in Glasgow. The Institution has saved during its history 45,000 persons from a watery grave, and of these no fewer than 613 have been rescued since January 1st of this year.

A STATEMENT of the receipts and expenditure in connection with the Royal Agricultural Show at Derby will be presented to the general meeting on the 12th December. It is estimated that the balance in the Society's favour will approximate the sum of £2000, which must be considered eminently gratifying after the losses in recent years.

THE Brazilian *Diario Official* of 4th November contains a copy of a Law sanctioning a scheme for the improvement of the water supply of Rio de Janeiro, which it is proposed to increase by about 98,000,000 litres per day. The cost of the scheme has been estimated at about £343,750, but this is only a preliminary estimate which must not be considered definite.

THE *Quinzaine Coloniale* states that the Public Works Department of Annam is about to be reorganised and strengthened by the appointment of specially qualified resident inspectors in the principal provinces. Several important projects are under consideration, among these being the provision of a supply of drinking water for Hué, and the lighting of that town by electricity.

REPORTING to the Hartlepool Port Commissioners upon the progress of the channel dredging operations in connection with the North-Eastern Railway Company's scheme for the extension of the docks, Mr. Hawkens, the Commissioners' engineer, announced that it was hoped to have a depth of 20ft. next year, but the dredging would have to extend 1000ft. from the present ending of the channel.

A NEW reinforced concrete hotel, under construction at Long Branch, California, collapsed recently, killing nine workmen and injuring many others. Five storeys of the central wing fell, burying the workmen under the *débris*. The cause of the accident is variously stated—faulty construction, removing of supports before the concrete was properly set, &c. The hotel covered an area of 348ft by 175ft., and four storeys had been completed.

THE tonnage of ocean vessels entering the port of Montreal this year up to November 1st was 1,795,090, as against 1,759,639 tons for the corresponding period last year, leaving increased tonnage for this year of 35,451 tons. The number of vessels increased from 751 to 758. Inland waterway trade also shows a decided increase; the number of inland craft coming into port since the opening of navigation to November 1st was 11,179, while for the same period last year the number was 9939, or an addition this year of 1240 vessels, with a proportionate increase in tonnage carried.

NINE-TENTHS of the gas-heating stoves for living rooms have Bunsen burners whose flames are choked with asbestos or iron radiators. The fumes then escape partly into the room even where there is no down draught in the chimney. Anyone who values his health should never use a Bunsen flame gas stove without making sure that no Bunsen fumes come into the room, says Mr Swinburne. There are gas stoves for living rooms with luminous flames and perfect combustion, but they are very uncommon. The gas stove might learn something from the electric stove. The object of a stove is not to heat the air that is in contact with it, but to radiate heat.

THE Gnat, the third to be completed of five coastal destroyers ordered from Messrs. John I. Thornycroft and Co., Limited, for last year's naval programme, was on Saturday successfully launched with all machinery on board from the company's Chiswick works. The dimensions of the class to which the Gnat belongs are:—Length, 168ft.; beam, 17ft. 6in.; draught, 5ft. 11in. The contract speed is 26 knots. The Gnat is fitted with turbine machinery of Parson's type, built by Messrs. Thornycroft, at Southampton, and Thornycroft water-tube boilers. The armament will consist of two 12-pounder quick-firing guns and three torpedo tubes.

THE demand for steam craft by the fishermen of the Fifeshire coast is much on the increase. Mr. James Miller, Anstruther, launched on the 1st inst. a steam drifter, to the order of Messrs. Gardner, Cellardyke. The vessel is 85ft. long, 18ft. 6in. broad, and 8ft. 6in. deep, and her machinery will be fitted by Messrs. John Cran and Co., Leith. This is the second drifter launched from the same yard since September; and, as showing the demand there is among fishermen for steam craft, Mr. Miller has orders on hand for another five of the same dimensions at a cost of £2500 each. For Anstruther alone about a dozen new steam drifters are building, or on order.

THE Central Emigration Board has been formed to encourage and assist in promoting the emigration of desirable and suitable persons from the United Kingdom to the British Colonies. The work will be conducted in strict accordance with the Immigration Laws, Rules, and Regulations in force in the several Colonies, and the Board's machinery will be open to all classes of the community desiring to settle in the Colonies It is intended to make the Board in every way representative, as will be seen by the names of those gentlemen who have already joined it; these include Sir Clement Kinloch-Cooke, chairman; Lord Hindlip, Sir William Chance, Bart., Sir Edward Stern, Lieut.-General Sir Edwin Collen, G.C.S.I., C.B., Sir Charles Bruce, G.C.M.G., the Rev. H. Russell Wakefield, the Hon. B. R. Wise, and Mr. Harold Boulton, M.V.B., with Mr. Edmund Storie as Hon. Organising Secretary. The offices of the Central Emigration Board are 70 and 71, Temple-chambers, London, E.C.

THE Corporation of the City of London, acting on the advice of Sir Benjamin Baker, K.C.B., have decided not to invite public tenders for the widening of Blackfriars Bridge. A selection has accordingly been made and twelve firms have been asked to tender for the work. These tenders are returnable by December 17th, the sum allowed by Parliament being £300,000. It was estimated that the work would take about 2½ years to complete, but the contractors will be allowed 36 calendar months, and will be paid a bonus of £20 for each day less employed; they will also be subject to a similar penalty for delay. The present bridge is 75ft. wide from parapet to parapet, having a roadway 45ft. wide between two footways, each of which has a width of 15ft. The new structure will have a roadway of 73ft. from kerb to kerb, and two footways 16ft. wide each. Thus, after allowing for the space required by the tramways, which will consist of a double track on the western side of the roadway, both carriage and footpath will have an increased width.

SPIRAL GEAR CUTTING MACHINES

GREENWOOD AND BATLEY, LIMITED, LEEDS, ENGINEERS

(For description see page 576)

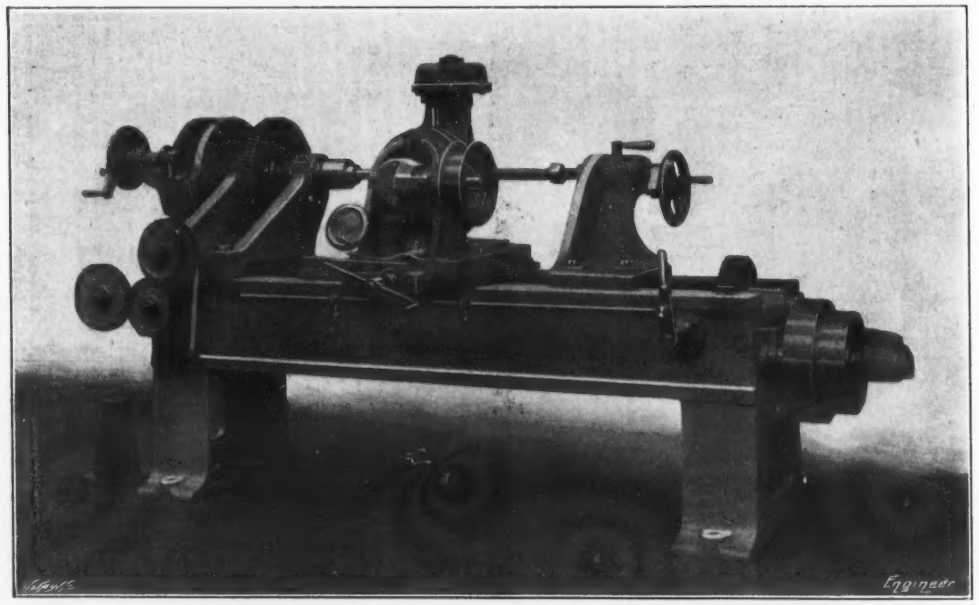


Fig. 3—24-INCH MACHINE—FRONT

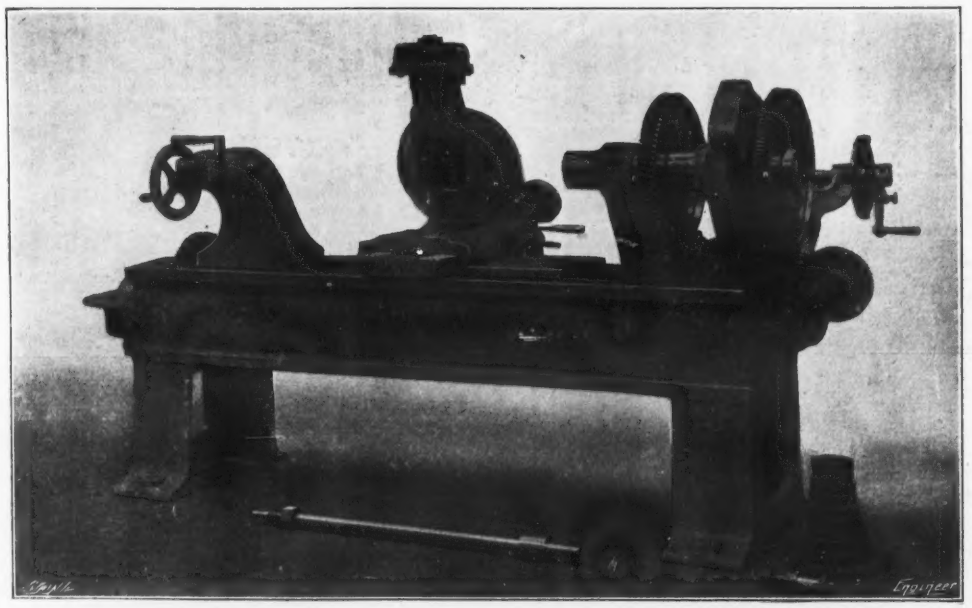


Fig. 4—24-INCH MACHINE—BACK

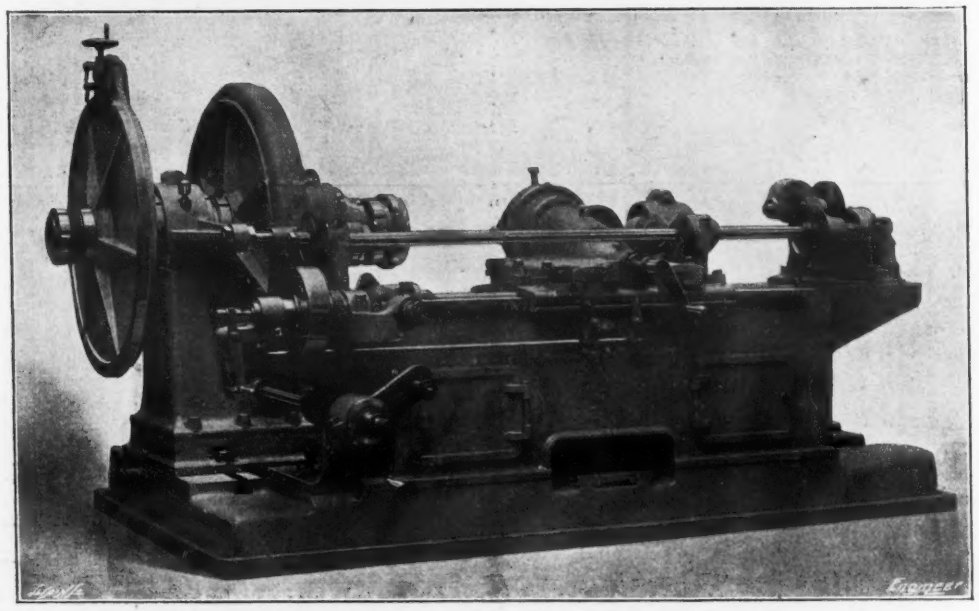


Fig. 5—46-INCH MACHINE—FRONT

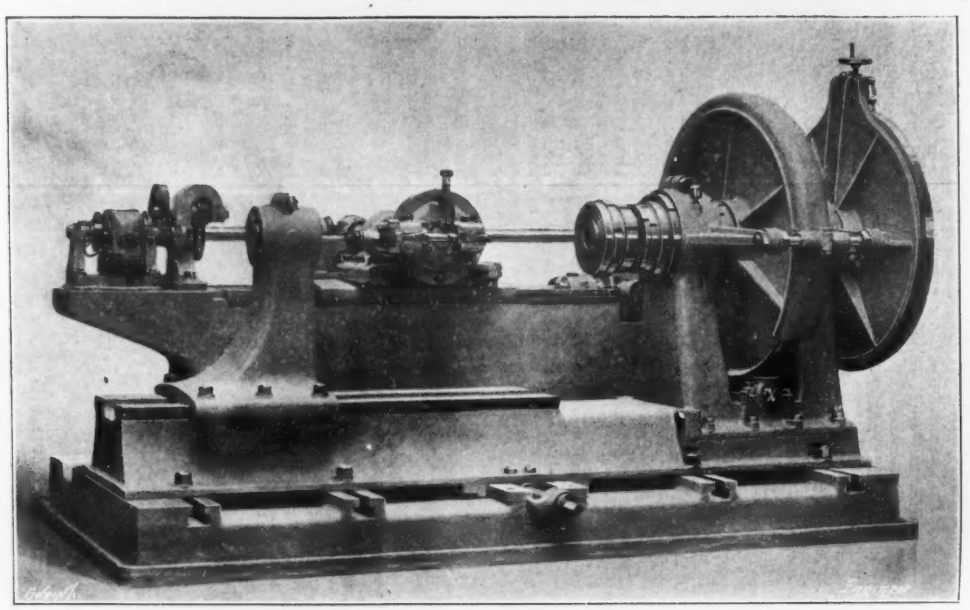
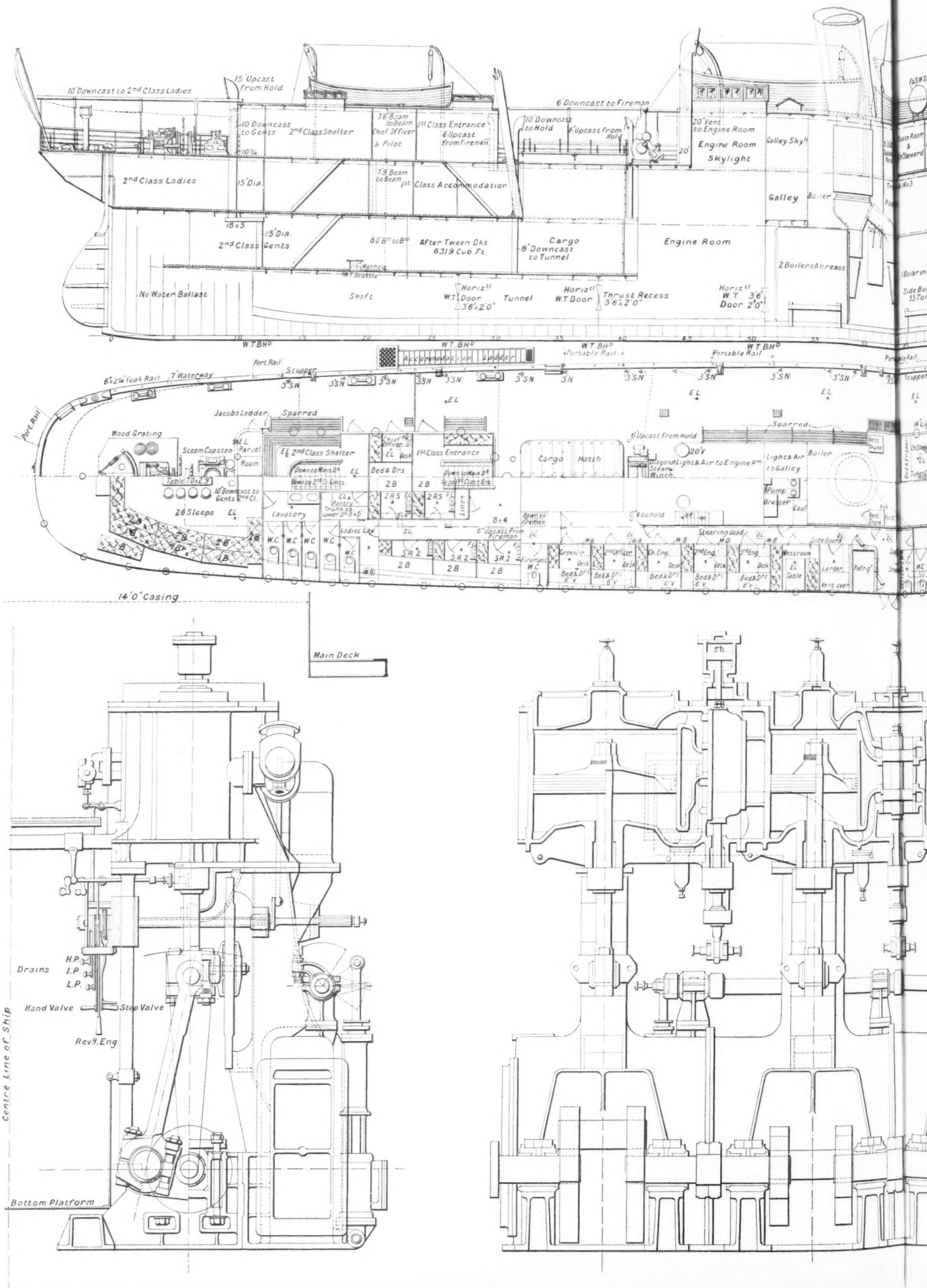


Fig. 6—46-INCH MACHINE—BACK

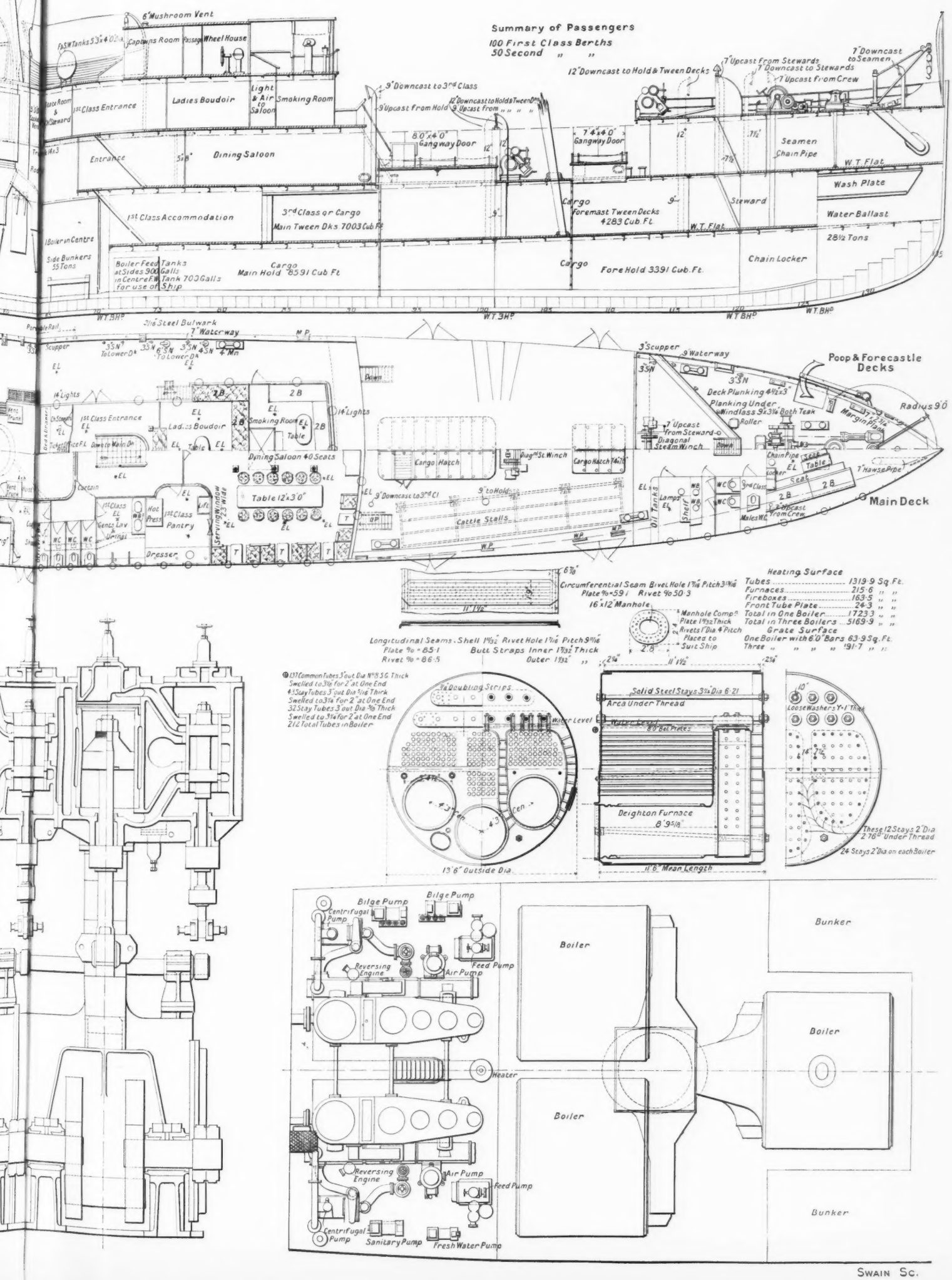
LONDON AND SOUTH-WESTERN RAILWAY—TWIN-S

GOURLAY BROTHERS AND CO., L



—TWIN-SCREW CHANNEL STEAMER PRINCESS ENA

OTHERS AND CO., DUNDEE, BUILDERS



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Advertisements cannot be inserted unless delivered before Six o'clock on Thursday evening, and, in consequence of the necessity for going to press early with a portion of the edition, ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

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PUBLISHER'S NOTICES.

*** *With this week's number is issued as a Supplement a Two-page Drawing of the Twin-screw Channel Steamer Princess Ena. Every copy as issued by the Publisher includes a copy of this Supplement, and subscribers are requested to notify the fact should they not receive it.*

*** *If any subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies*

REPLIES.

INTERESTED.—We agree with you. The explanation as it stands is quite incomprehensible. Why not try the experiment?

H. H.—You could no doubt obtain full particulars from Messrs. Field and Morris, of 4, Trafalgar-square, Charing Cross.

A. Y.—We are unable to help you. We made inquiries ourselves at the show, but did not succeed in finding the machine.

H. F. D.—Further particulars are, we understand, not yet available. The address of the inventors is 4, Trafalgar-square Charing Cross.

H. B.—You cannot do better than get a copy of Mr. Humphry's paper on "The Mond Producer," read a few years ago before the Institution of Mechanical Engineers. A valuable book on "Producer Gas," by Mr. Dowson, has recently appeared, the publishers are Longmans.

SWINDON.—You will find a list of the directors and staff of the Canadian Pacific Railway in the "Universal Directory of Railway Officials." This book you will nearly certainly find in any public library. If, however you do not do so, we shall be pleased to help you further in the matter.

WORKER.—It would take a volume to answer your questions. See the long series of articles on the "Commercial Organisation of Factories," recently concluded in these pages, and such books as Burton's "Commercial Management of Engineering Works," Hawkins' "Cost Accounts," and Slater Lewis's "Commercial Organisation of Factories." We publish scores of descriptions of engineers' tools every year.

R. T. (Peterborough).—We cannot, we fear, direct you to any very definite source of information; you will find some evidence, however, in the course of the discussion on Mr. Churchward's paper on "Large Locomotive Boilers," read before the Institution of Mechanical Engineers in February, 1906, and particularly M. Sauvage's paper on "Compound Locomotives," Institution of Mechanical Engineers. March, 1904. Again, as regards the influence of the size of wheels on common roads, you might consult Youatt on "The Horse," see the section on mail coach work and draught.

MEETINGS NEXT WEEK.

THE ENGINEERING SOCIETY.—Wednesday, December 12th, at 8 p.m., at East London College. Paper, "The Design of a Petrol Motor," by A. P. Thurston, B.Sc.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, December 10th. Paper, "Up-to-date Milling Machines," by Mr. A. B. Symons.

INSTITUTE OF MARINE ENGINEERS.—Monday, December 10th, at 8 p.m., at 58, Romford-road, Stratford, E. Lecture on "Electricity," with illustrations, by Mr. A. E. Battle.

INSTITUTION OF ELECTRICAL ENGINEERS: LEEDS LOCAL SECTION.—Thursday, December 13th, at 7.15 p.m., at the University, Leeds. General meeting. Paper, "Practical Photometry and its Value," with practical demonstration, by Mr. Haydn Harrison.

INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, December 12th, at 7.30 p.m., in the Large Lecture Theatre, The University, Edmund-street. Ordinary general meeting. Paper, "The Heating of Magnet Coils," by G. A. Lister, B.Sc.

THE ROYAL SCOTTISH SOCIETY OF ARTS.—Monday, December 10th, at 8 p.m., in the Hall, 117, George-street. Communication. "On the Construction and Working of the Willans-Parsons Steam Turbine," by Mr. E. G. Izod, Assoc. M. Inst. Mech. E. (With lantern illustrations.)

THE INSTITUTION OF CIVIL ENGINEERS: ASSOCIATION OF YORKSHIRE STUDENTS.—Thursday, December 13th, at 7.30 p.m., in the Council Room of the Leeds Chamber of Commerce, Exchange-buildings. Ordinary meeting. Paper, "Details of Locomotive Design affecting Bridgework," by Mr. E. S. Pink, Stud. Inst. C.E.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION OF STUDENTS.—Thursday, December 13th, at 7.45 p.m., in the Lecture Theatre of the North of England Institute of Mining and Mechanical Engineers, Neville Hall, Neville-street Paper, "Some Observations of a Mining Engineer in America and Canada," by Mr. Walter Rowley, M. Inst. C.E.

THE FARADAY SOCIETY.—Tuesday, December 11th, at 8 p.m., in the Library of the Institution of Electrical Engineers, 92, Victoria-street, S.W. Ordinary meeting. Papers: "On the Electro-chemistry of Lead," by A. C. C. Cumming, D.Sc. "Contributions to the Study of Strong Electrolytes," by A. C. C. Cumming, D.Sc. "Storage Batteries and their Electrolytes," by R. W. Vicarey.

SOCIETY OF ARTS.—Monday, December 10th, at 8 p.m., at John-street, Adelphi, London, W.C. Cantor Lectures: "Artificial Fertilisers, their Nature and Functions," by A. D. Hall, M.A., Director of Lawes' Agricultural Trust. Wednesday December 12th, at 8 p.m. Ordinary meeting "Fruit Growing and the Protection of Birds," by Cecil H. Hooper, Member of the Council of the National Fruit-Growers' Association. Thursday December 13th, at 4.30 p.m. Indian Section. "The Indian Mohammedans: Their Past, Present, and Future," by A. Yusuf Ali, M.A., LL.M. (Cantab.), I.C.S.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 11th, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Discussion on papers: "The Talla Water Supply of the Edinburgh and District Waterworks;" "Repairing a Limestone Concrete Aqueduct;" "The Yield of Catchment Areas." Paper, "Mechanical Considerations in the Design of High-tension Switch Gear," by H. W. E. Le Fanu, M. Inst C.E. Wednesday December 12th, at 2.30 p.m. Students' visit to the Wire Rope Works of Messrs. Bullivant and Co., Limited, 38, West Ferry-road, Millwall, E. Friday, December 14th, at 8 p.m. Students' meeting. Paper, "Mechanical Improvements in the Drainage of the Bedford Level," by A. Carmichael, Stud. Inst. C.E.

DEATH.

On the 30th November, at Savoy-court, Strand, London, Sir EDWARD JAMES REED, K.C.B., F.R.S., in his 77th year, of heart failure.

THE ENGINEER.

DECEMBER 7, 1906.

The French Marine.

THE debate recently concluded in the Chamber of Deputies upon the construction of the six battleships for which contracts have been given out by the Minister of Marine, in pursuance of a special vote in the last session, may be expected to have put an end to the opposition which the Conseil Supérieur de la Marine has for years past been contending with in its endeavour to carry out a systematic policy of naval construction. The opposition comes from a class which cannot relinquish the idea that the whole art of naval strategy lies in the concentration of small units, such as submarines and submersibles, torpedoes, and destroyers. The fallacy of this idea has been so often exposed that it is surprising to find deputies taking up so much time in advocating the cause of this chimera. The reporter on the Naval Estimates, M. Henri Michel, has, apparently, made out the best case possible for the submarine and submersible; it may be summed up in a few words. The increasingly heavy deficit of the Budget does not allow of France spending such huge sums as are necessary to keep pace with England and Germany, even if her shipbuilding resources would enable her to do so, and, in view of this inferiority, he is of the opinion that the only policy France can safely adopt is to take advantage of her superiority in submersibles and submarines as a weapon of attack against costly battleships. Another reason why the reporter objects to the placing of contracts for the six battleships is that the Minister of Marine would not get such favourable terms for their construction as he would do if he extended the orders over a number of years. M. Michel points to the fact that all the shipbuilding firms are now busy on Government contracts, and that iron and steel makers and others who tender for State orders have recently combined with the idea, he alleges, of forcing the Government to pay higher prices. He thus finds another argument against the immediate construction of more than three battleships in the assertion that by overloading the shipbuilders and iron and steel firms with work the Government is recklessly squandering a large amount of public money.

We do not propose going into the attacks on the programme of M. Thomson, who is accused of sacrificing the flotilla of submersibles and submarines, and even the armoured cruisers, to the new requirements in powerful battleships. M. Thomson had no difficulty in presenting arguments which silenced his opponents and secured the approval of the Chamber for the building of the six new vessels. He pointed out that the submersible and the submarine in their present form were far from being such efficient weapons of defence as was claimed by the advocates of a numerous flotilla of small boats. Repeated experiments were carried out during the past year, and had shown that the submarine was very effective for harbour defence, to the extent even that the blockading of a port afforded considerable difficulties, but the submarine and submersible can only be employed in the daytime, and at night they have to be replaced by the torpedo boat. The utility of the small boats was therefore strictly limited to coast defence, and every attempt that had been made to carry on experiments at sea had failed. During the Channel manœuvres the submarines were set the task of discovering and attacking battleships and cruisers within a radius of 10 miles. In no single case do they appear to have succeeded. It is found almost impossible for a submarine, with its present system of periscope, and necessarily low speed under water, to discover the position of a battleship and get within striking distance when the latter is steaming at anything like high speed. This does not imply that the French have lost faith in the submersible and the submarine as weapons of attack, since there are evidently plenty of improvements to be carried out, and recent experiments and trials with a view to selecting the most suitable kind of motive power to be fitted to much larger submersibles than have up to now been constructed, show that the French still have plenty of confidence in their ability to increase the fighting efficiency of the new type of vessel; but until they have evolved a more serviceable type the French marine is not disposed to embark recklessly upon the construction of submarines and submersibles which are likely soon to become obsolete. For the moment they are being employed purely for harbour defence. Until the last year or two Government has, under pressure of the Chamber of Deputies, been engaged almost exclusively in strengthening the fleet of small vessels, as well as the armoured cruisers, of which there are now 24, the oldest being the Latouche Tréville, built in 1892, and being for the moment sufficiently equipped with such vessels, the Conseil Supérieur de la Marine thinks that the time has come for strengthening the first line of defence by putting in hand the six battleships which have already been ordered by the Minister.

While the construction of the six first line battleships was sanctioned in March last, the placing of orders has been delayed pending the trials carried out with the Dreadnought. As the result of these trials the plans were modified to increase the speed from 18 to 19 knots, and to fit the ships with steam turbines instead of reciprocating engines, as originally specified. The Minister claims that in many respects the new battleships will be quite as

powerful as the Dreadnought. To meet these new requirements the guns have also been improved in the way of increased initial velocity and greater weight of shells. The new 240 mm. gun will fire a shell of 220 kilos. with an initial velocity of 875 m, as against 170 kilos. and 830 m. for the older type. In the case of the 305 mm. gun the initial velocity is only increased by about 5 per cent., but the weight of the shell has been raised from 340 kilos. to 440 kilos. This gun will fire two rounds per minute, while the 240 mm. gun will discharge three per minute. By taking into account the rapidity of fire, the Minister affirms that the new battleships will be slightly superior to the English and nearly equal to the German. The figures he gives of the weight of metal discharged per minute are as follows:—Ahead, 4400 kilos. for the French battleship, 4620 kilos. for the English, and 4635 kilos. for the German; broadside, 7480 kilos. for the French, 6160 kilos. for the English, and 7650 kilos. for the German; astern, 4400 kilos. for the French, 1540 direct astern and 3080 kilos. at a slight angle for the English, and 4635 kilos. for the German. M. Thomson fully believes that the new battleships will steam at more than 20 knots an hour, and having a range of action of 8000 miles, they will be as powerful and efficient a unit as the new English or German battleship. It is intended to class the French battleships into three categories, the six under construction forming a class apart, while there will be twelve first-class battleships and eight second-class, thus making twenty-six in all. Some of these, however, are already old, and in a few years will become obsolete.

The new programme of M. Thomson may be taken as marking a decided step in advance towards the creation of a homogeneous fleet, and, as he stated in the Chamber, his idea is to utilise all the different elements of efficient attack and defence, instead of sacrificing one type of vessel to another, as has been done in the past.

Railway Fog Signalling.

AT the adjourned inquest held on Tuesday last on the bodies of the driver and fireman of the express from Scarborough to Leeds that came into collision with a train of mineral empties at Ulleskelf, near York, on the evening of November 24th, a verdict of accidental death was returned. The facts were briefly referred to in last week's issue of THE ENGINEER. The express was travelling on the up Leeds line, but as the mineral train was occupying that road at Ulleskelf the signalman at the box in the rear—Bolton Percy—arranged to turn the express on to the up Normanton line, after a Lancashire and Yorkshire train had passed along the latter line. He therefore kept his distant and home signals at danger against the express, but the driver ran past them, also past the Bolton Percy starting signal and Ulleskelf distant. The man at Bolton Percy telephoned forward what had happened, and the guard of the mineral empties ran back with a red light. Whether it was this warning or the three red lights on the brake van that caused the driver to take action is not known, but after travelling at full speed he appears to have suddenly shut off steam and applied his brakes fully as the train was running through Ulleskelf station. This was too late, and a collision occurred. Very little personal injury was caused to passengers, but the driver and fireman of the express were both killed. This is to be regretted for other reasons than the sacrifice of life. It removes, as in the Grantham, Salisbury, and Aylesbury accidents, the only persons who can explain the reason for the accident. In this case it is not clear why a driver should run past four signals at danger—signals that are well-placed and by the side of the line they apply to, and separated from those for the Normanton line. There is no doubt that there was a fog of varying density, and allowance must also be made for the steam from the Lancashire and Yorkshire train which was about two trains length in front. The guard of the express said that he did not see any signals at Copmanthorpe—the station before Bolton Percy—nor anywhere else, although he was looking out of the van all the way for the purpose. Neither did he see the station or the lights of the station or signal-box. On the other hand, the stationmasters and signalmen at Bolton Percy and Ulleskelf said that the fog was not thick enough for the fogmen to be called out, and, as a consequence, they were not out. These are, however, the statements of interested parties, and that the fog did interfere with the view of the signals is supported by the evidence of drivers of other trains who had passed over the same ground just previously, and these men said that they could only see some signals 20 yards away. If, then, to the difficulty of seeing signals in fog is added the obstruction caused by the steam from a train in front being blown across the lines—which, it is proved, did happen—then it is fair to conclude that the driver of the express failed to see the lights of those signals that he ignored.

Why, then, did he not act up to Rule 144, and assume that the signals not seen were at danger? To answer that question, it may be useful to refresh one's memory of the facts of the Cudworth collision of January, 1905. This was dealt with in THE ENGINEER of February 10th, 1905, and April 28th, 1905, and it is somewhat surprising to find how the circumstances of Cudworth are paralleled at Ulleskelf. At Cudworth the fog came on late at night, when, of course, the platelayers, who act as fogmen, were off duty. At Ulleskelf the collision occurred about 7.25 p.m., and it is stated that the fog had been hanging about since about half-past five, but being Saturday the platelayers had gone home, so that it would be necessary to despatch a messenger to bring them on duty. The signalman at Bolton Percy, as at Cudworth, did not act up to Rule 85 and put detonators on the rail in addition to keeping his signals at danger. Then, lastly, as at Cudworth, the driver was no doubt misled by not hearing any explosion of detonators, and assumed that the signals were at clear. He would be justified in this by our antiquated system of fog-signalling, as the detonators are withdrawn from the rail when the signal is lowered; and whilst the regulations lay down that a green hand signal has to be shown instead, yet, as explained in our Cudworth article, this signal cannot be given in some cases. It seems incredible that this should be so; but it is, nevertheless, a fact that under such conditions as those that prevailed at Cudworth and at Ulleskelf, the absence of a signal indicates "line clear." The only safeguard against this is for the signalmen to put detonators on the rails; but this, as Major Pringle pointed out in his report on the Cudworth accident, is not always practicable. At least, it was not so at Cudworth, where, the Major said, "I do not consider that any of them, under the circumstances, could be ordinarily expected to lay detonators in accordance with the rule. The working of the traffic would be entirely disorganised, and the attention of the men dangerously distracted from their important duties in connection with signalling."

Although it is nearly two years since attention was drawn to these weaknesses, nothing apparently has been done, and one might assume that there is no remedy. There is, however, a remedy to be found in mechanical fog-signalling, to which Major Pringle referred favourably, and which he said possesses "the great advantage of being available for use at all times;" and now we trust that the Board of Trade will take a firm stand on this matter, as the companies' attention was drawn officially to the question so long ago as December, 1899—seventeen years ago—after the Wivelsfield accident. The North-Eastern, strangely enough, is the only company which has mechanical fog-signalling in general use. It employs Raven's apparatus between York and Darlington, and Newcastle and Berwick; but it was not fixed at Ulleskelf owing to other companies' engines running over that stretch. That is an obstacle to the use of such a system, but it is more apparent than real, as we may rest assured that if a good apparatus were brought out it would be universally adopted, as was the chain communication. Raven's apparatus has, however, one fault. It is included in those referred to by Major Pringle which do not give a dual indication, *i.e.*, no signal is given if the signal is clear. There are, however, other systems which apparently meet all the conditions, as, for example, one which the Great Western Company has designed and is experimenting with. Possibly the other companies are waiting for the results of what the North Stafford and Great Western are doing, but after having had seventeen years to consider the question, and with the lessons of Cudworth and now of Ulleskelf before them, it really does seem time that an effort should be made to make railway travelling in fog more secure.

The International Rail Syndicate.

IT is understood that negotiations are on the point of being commenced with a view to the renewal of the International Rail Syndicate which was formed over two years ago, and which will nominally expire at the end of next June. The parties to the convention, it will perhaps be remembered, are the principal producers of rails in Great Britain, the rail-rolling mills included in the German Steel Syndicate, and the Belgian and French rail producers. It is just possible that the steel exporters in the United States also belong to the Syndicate either directly or by means of an indirect arrangement, probably concluded with the German Steel Syndicate subsequent to the signature of the original international rail agreement in 1904. The object of the Syndicate, which solely relates to the trade in heavy rails, was the division of the markets of the world among the constituents of the combination by the apportionment among them of the estimated aggregate consumption on a percentage basis, and the regulation of prices in such a manner that the producers in one country should not undersell those of any one of the other countries concerned. The total tonnage allotment of the British firms comprised slightly over one half of the aggregate, and the German Steel Syndicate accepted somewhat more than a quarter, whilst the balance was accorded to the Belgian and French rolling mills. But some re-arrangement of these figures, which were arrived at on the constitution of the Syndicate, must of necessity have been made if, as is believed, the export department of the United States Steel Corporation became associated with the combination in some form or other at a later date. No doubt the agreement has been of considerable value to the continental works interested in it, inasmuch as it has assured them a definite share in the world's demand. The British firms were and are similarly situated, although they have found a decided difference between the freedom of action which formerly prevailed and the restrictions which are imposed by the operation of the agreement.

The first action of the Rail Syndicate over two years ago was to fix the export prices of rails at £4 5s. to £4 10s. per ton at the port of shipment; to-day the price is from £5 15s. to £6 per ton. But the condition of the iron and steel trade is at present materially different from what it was in 1904, and the advance of £1 10s. per ton may only in part be attributed to the formation of the Syndicate, having regard to the prosperous state of business on the one hand, and to the rise in the prices of raw materials and of labour on the other. The question of price is, however, not everything if the export market has to be temporarily neglected by the rail constituents of one nation—when they have secured orders representing the maximum tonnage of their allotments for the time being—in order to allow the other parties who may be in arrears to reach the percentages to which they are entitled. It is precisely this position of affairs which is believed, under the present division of markets, not to have been relished by the British firms, as they have been compelled to hold aloof from certain contracts so as to permit others to clear off arrears. As, however, this contingency must, or should, have been foreseen on the conclusion of the agreement, it is useless to complain while the arrangement remains in force. How the rail convention has operated in the current year is demonstrated by the fact that the exports from the United Kingdom in the first ten months declined by 71,000 tons, as compared with the corresponding period of 1905, the figures being 393,000 tons and 464,000 tons respectively, while the exports from France diminished by 3000 tons in the same period. On the other hand the exports of rails from Germany, which amounted to 171,000 tons in the first eight months of 1905, advanced to 222,000 tons in the same term of the present year, being an increase of 51,000 tons, and a further augmentation is reported to have taken place in September and October. The exports from the United States in the first nine months of this year were 250,000 tons, as compared with 210,000 tons, and those from Belgium were 135,000 tons in the ten months, as contrasted with 111,000 tons in the equivalent period of 1905, being advances of 40,000 tons for the United States, and 24,000 tons for Belgium. These figures represent a total gain of 115,000 tons for the three countries in question, whereas Great Britain has incurred a loss of 71,000 tons, as already mentioned.

It is with the reflections set forth that negotiations are being opened having as their object the prolongation of the Steel Rail Syndicate. To these have to be added the consideration that fresh competitors in the markets of the world have arisen since the conclusion of the existing agreement in 1904. These are the Spanish Altos Hornos, of Viscaya, one or two Austrian rail rolling mills, and one or two Russian works, whilst the advent of a firm in the North of England is of more recent date. If the Rail Syndicate is to be renewed it will probably have to include these outside firms, excepting, perhaps, the Russian producers whose appearance as successful competitors was due to exceptional circumstances. The question arises as to whether it would be of advantage for the British constituents to continue the arrangement, and it would be interesting to hear their views on the subject. Apparently the initiative in the matter of prolongation has emanated from the German Steel Syndicate, the representatives of which are reported to have been authorised to agree to the conclusion of a new

agreement on the basis of the existing convention for a period of five years, although on the condition that if the German Steel Syndicate itself is not renewed on the expiration of the present contract at the end of June, 1907, the Teutonic interests should have the right to give notice to terminate the Rail Convention on December 31st, 1907. In the circumstances, it would seem that the proposal for prolonging the Rail Syndicate needs exceedingly careful consideration on the part of the British constituents before they again decide the question of committing themselves to the scheme. It will be necessary to examine the gains and losses in the past two years, and when a balance has been struck it should be possible to arrive at a conclusion as to whether renewal is desirable or would be advantageous, especially as the fate of the German Steel Syndicate itself remains undecided and is difficult to settle.

A Further Development of the Atomic Theory.

IT behoves engineers to take cognisance of any important advance made in the science of chemistry, for so dependent are engineers on the sister science that any progress therein is bound to be reflected on engineering methods at no distant date. Engineers, therefore, in common with other scientists, will hail with acclamation a paper which has recently been read before the Chemical Society by Mr. Barlow and Professor Pope, and which may truly be said to mark the commencement of a new era in the history of chemistry. With the inception of the atomic theory, commonly accredited to Dalton, chemistry as a science may be said to have taken its origin. This was just a century ago, and from that date the theory has not only held its ground, but has been a very potent factor in the progress of the science. What Dalton has done for chemistry in the past, it may be said that Barlow and Pope do for chemistry to-day, in the further development of that theory which they present to the scientific world. Hitherto a theory, it must now be elevated to the rank of fact, if the arguments brought forward are to be admitted—arguments which, backed by the great weight of evidence that the authors have brought forward, would appear well nigh irrefutable. It must be left to the chemist and mathematician to pass the final verdict on the validity of the views submitted, but no one can refrain from admitting the extreme plausibility with which those views are clad.

Space will not admit of an adequate account of this extremely interesting paper; we can only pass briefly in review the principal points involved. The theory consists in regarding the atom as possessing a sphere of influence within which no other atomic sphere of influence can trespass, and matter as being built up by the aggregating together of a number of such spheres of influence. The volume of the sphere of influence determines the valency of the atom, for reasons which will be immediately developed. Each sphere exerts on its neighbour an attractive force—probably of the nature of gravity—and at the same time a repulsive force, which may be regarded as due to dynamic movements within the atom. The effect of these oppositely exerted forces is to give to a collection of such spheres a tendency to assemble in such manner as will include the largest number in a given space. Such a state is generally to be attained by a symmetrical or "ordered" arrangement, consisting in the clustering together of an indefinitely large number of simple similar groupings, each consisting of two or more spheres, and it is on the geometrical properties of such assemblages that the authors base their conclusions. The similar groupings constituting an assemblage are regarded as molecules, themselves containing in ordered array the constituent atoms This fundamental conception, being purely of a geometrical nature, lends itself to geometrical treatment. It is clear that in such an assemblage of groupings of spheres, one sphere may be substituted for another in a group without disturbing the general arrangement, provided it is equal in volume to the sphere which it replaces, *i.e.*, provided it has the same valency. This is in accordance with chemical fact. If, however, the substituting sphere has a volume double that of the substituted, then a distortion or production of gaps results, which can only be filled by the addition of another sphere of volume equal to that of the substituted sphere. Here, again, there is entire correspondence with chemical phenomena; if in the molecule HCl, for example, the divalent atom Ca is substituted for the monovalent atom H, then, in order to restore the condition of close packing which previously prevailed, it is necessary to add another monovalent atom—for example, Cl, when we obtain the stable compound $CaCl_2$. In like manner, the theory is found to account satisfactorily for every other known law of valency.

It is when we come, however, to the study of crystalline form that the most striking correlations are met with. Case after case is cited by the authors wherein the relations subsisting between the crystalline forms assumed by substances are directly correlated with the postulated geometrical disposition of the atoms, and wherein the arrangement of the atoms in the molecule is in direct accord with the known chemical and physical properties of the substance.

It is impossible, with the limited space at our disposal, to do more than indicate, as has been done above, the nature of this theory. Its importance can scarcely be over-estimated when it is considered that by its means we are enabled to visualise, not only the actual positions taken up by the atoms within the molecule, but also the disposition and arrangement in space of the molecules themselves, and already it has yielded an abundant harvest of suggestion and deduction to its able exponents. The scientific world will watch with attention the further developments to which this theory may lead, and it would scarcely appear too much to expect that at no very distant date chemical and physical properties of substances in general will be predicated simply from the geometrical arrangement of the atoms within the molecule.

The Conduct of Discussions.

THE discussion of Mr. Clarkson's paper on the Clarkson steam omnibuses—for that is what it really is—at the Institution of Mechanical Engineers has now occupied the greater part of the time of one meeting, all the time of another meeting, and will again be resumed on Friday evening, the 14th inst. So far, it has been quite unsatisfactory—unsatisfactory, indeed, to such degree that, in the interests of the Institution, we must enter a protest. We do not intend to mention names; we have reported what the speakers said, and that is sufficient; indeed, it fills the whole question.

Let us ask ourselves what is the purpose of a discussion? The reply is obvious. It is intended to supply useful information or valuable expert criticism. Let us apply this standard to the discussion under notice. The fact is that only two—or at the most three—speakers satisfied the conditions we have laid down. The impression conveyed by the majority of the speakers was simply that they had not sufficient practical acquaintance with steam omnibuses to enable them either to put intelligent questions or contribute useful information. But this is not the worst. The attendance has been very large, the members and visitors full of interest and expectancy. There was no lack of speakers. The President was from the first moment anxious to "get on." But at least one-half the speakers were diffuse to the last degree. Mr. Clarkson was simply drowned in a torrent of eulogy. He was obsequiously thanked and rethanked for reading his paper. It might be imagined that he had conferred an enormous obligation on the whole profession by publishing a description of his steam omnibus. The fact that the Institution exists for the purpose of obtaining such information for its members was entirely overlooked. We have before now suggested that every purpose would be satisfied if an analogue of the Thibetian prayer wheel were put up in the hall, and that each speaker should give it a twirl as he passed, so registering his appreciation of the goodness of the authors of papers. It is quite time that this wasteful practice of praising and thanking the readers of papers was given up. Life is far too short for it. The formal vote of thanks always proposed and passed with acclamation is all that is consistent with the dignity of an Institution holding a high position.

Again, it is noteworthy that those who had least to say of value were those who spoke at the greatest length. There is an excellent but unwritten rule that no speaker in a discussion shall occupy more than ten minutes of the time of the meeting. It is unfortunate that the enforcing of this rule may place the chairman in an invidious position. It must happen now and then that in the Institution of Mechanical Engineers the President is personally interested commercially in matters which may be made the subject of discussion, and an attempt to check a speaker may be regarded as an endeavour to stifle a rival. It is desirable, therefore, that it should be unnecessary for him to interfere. The conditions would be met by copying the practice of the ancient Scottish preacher. An hour-glass stood on the pulpit, and the sermon was expected to end with the running of the sand. Instead of a glass, let a clock stand on the Council table, and ring a loud alarum at the end of ten minutes, and keep on ringing until the chairman pressed a button. The clock would be started with the rising of each speaker. If the meeting desired more, another ten minutes might be given by vote. In this way the speaker would get due warning that his time was up, without any interference on the part of the chairman. Or the duty of checking long-winded speakers might devolve on the Secretary.

Finally, we may say that nothing seems more remarkable in the conduct of discussions than the tendency they manifest to run into side issues, those really relevant being quietly suffered to drop out of sight. We have heard of an agricultural discussion on breeding pigs which ended in an acrimonious argument about bridges on parish roads; and of another about the strength of cast iron pipes which went off to the management of brass foundries. In some cases nothing but the most determined efforts on the part of the chairman can keep speakers to their text. In the case of Mr. Clarkson's paper, it is the more to be regretted that the discussion has, so far, been futile. We live in hope that the concluding discussion will supply the deficiencies of those which have preceded it.

Scottish Shipbuilding.

THE tonnage of new shipping produced by Clyde shipbuilders during the eleven months of 1906 now closed is considerably greater in amount than that floated during the whole twelve of any previous year. The total output last year, of about 539,850 tons, formed a record, but the figures available for the eleven months of this year show an increase of over 11,000 tons where the Clyde district alone is concerned, and of nearly 16,000 tons for the whole of Scotland. Not only so, but a large number of the smaller class of vessels and the light-draught class usually shipped abroad in pieces, which do not figure in any monthly statements, has to be included in the complete returns for this year, so that by the end of December both the number of vessels and the aggregate tonnage will be very considerably higher than for any previous year. This result has somewhat surprised many interested in, but not closely in touch with, the shipbuilding industry on the Clyde, it having been generally supposed that the recent strike had destroyed all chance of 1906—notwithstanding that it has been "the year of big ships"—breaking last year's shipbuilding record. Before the strike began on October 1st, it was regarded as certain that 1906 would prove equal at least to 1905, but when seven weeks went past without a settlement having been effected, it appeared unlikely that anything more would be attained. A good deal of the work on hand, however, was almost at the launching stage, having been placed during the "boom" in the early part of the year; and both of the months affected by the strike were accordingly enabled to show a fairly good average. With the vessels still to be launched, and with the addition to the figures of the "shipped" tonnage, &c., before alluded to, there is every likelihood of the year's total reaching the unprecedented figure of close on 600,000 tons—or, say, 50,000 tons over last year's record. As to the prospects before the industry, there is nothing commensurate with the briskness which all the foregoing betokens. The yards have been greatly depleted during the past five or six months, and as there is little chance of any immediate reduction in the price of materials, and quite as little prospect of the state of shipping freights improving, builders are unable to quote tempting terms for fresh contracts. Happily, there is not likely to be any serious labour dispute for four months at least, and this prospect of itself will help to promote inquiries, if not actual contracts. The number of inquiries have appreciably increased since the end of the recent strike, but the contracts actually booked are few.

Trades Disputes Bill.

ON Tuesday last the Trades Disputes Bill was read for a second time in the Upper House without a division. It is, therefore, fairly certain that it will pass the final stage with little opposition, and that it will become law. Without relinquishing one particle of the opposition which we have shown to it from the first, we are obliged to admit that the course dictated by Mr. Balfour is probably from a political aspect the right one. The Bill is, in a sense, a popular measure, and it is possible that a direct appeal to the country—if that should happen—would be in its favour. Let, then, the country and the Party which has introduced it take the responsibility for the measure. Of one thing we may be fairly sure. For some time to come labour will refrain from abusing the advantages it gets under it from sheer shame of disgracing its own offspring. On the other hand, should the unions use the power it gives to bad purposes, means will be found by a future Parliament to restore a more equitable condition.

SIR EDWARD JAMES REED.

THE death of Sir Edward Reed, K.C.B., on the 30th of November, has removed a man whose career for several years was a matter of national importance. He was born in 1830, at Sneerness, of humble parents. He appears to have had little education, being employed in the dockyard; but he was one of those who, insisting on getting to the top, gets there in spite of obstacles. There was a school of mathematics and ship construction at Portsmouth, and to this he found his way, and profited largely by what he was taught. He married early in life Miss Barnaby, the daughter of an inspector of shipwrights at Sheerness Dockyard, where Mr. Reed worked for several years. Ultimately he came to London, and was for some months editor of the *Mechanics' Magazine*, and subsequently a contributor to the columns of THE ENGINEER. He had much to do with the founding of the Institute of Naval Architects by his brother-in-law and John Scott Russell, and was for some time its secretary.

The most important fact in his life was his appointment to the post of Chief Constructor of the Navy; precisely why the appointment was made we are unable to say. It would be impossible within the space available to give an adequate idea of the chaotic conditions which prevailed at Whitehall from the year 1863, when he took office, for more than fifteen years. The appointment was only worth £800 a year, and carried little honour with it. The Chief Constructor was, indeed, regarded as not much more than a leading shipwright. The Admiralty never originated anything, and was conservative to the last degree; but the world progressed in spite of the Admiralty. Steam came; its use in the Navy was advocated by Reed, and he got much help from Sir Spencer Robinson, the Controller. It is not perhaps matter for surprise that steam was not favoured. Engines and boilers weighing 700 tons, indicating 800 horse-power, and imparting a speed of six knots to a cut-down battleship, were not likely to be popular with men who could almost remember Nelson. Reed succeeded, however, in introducing a new type of warship. With the Warrior he had much to do, and other ships which are now obsolete followed in rapid succession.

Mr. Reed favoured the turret system, although he was bitterly opposed to the cupola system of Captain Cowper Coles. The latter wanted a low freeboard, so as to present a small mark to an enemy, and he introduced tripod masts of iron, instead of the old wooden mast with shrouds. A ship with cupolas—the Captain—was built to Captain Coles' designs by Messrs. Laird; she was intended to have a freeboard of 8ft., but so much was added in the way of weights that at last it was only 6½ft. At midnight, off the coast of Spain, in a moderate gale, under three topsails, she was caught in a squall, upset, and sank on the 7th September, 1870, her designer, Captain Coles, and her captain, H. T. Burgoyne, and all her crew, save a very few, going down with her. Mr. Reed had foretold disaster. He would have nothing to do with the design of the Captain, and in point of fact resigned in 1870, his place being taken by his brother-in-law, Mr., now Sir Nathaniel, Barnaby. During his term of office Mr. Reed gave the Navy many noteworthy ships, including the Devastation, Bellerophon, Hercules, Sultan, and others long since forgotten, making about forty in all. After he retired from the Admiralty he undertook private business, and designed many vessels for foreign navies. He sat in the House of Commons from 1874 until 1895. In Mr. Gladstone's administration he was made a Lord of the Treasury, and received his K.C.B. He was a somewhat voluminous writer on various subjects, ranging from iron shipbuilding to Japan.

Sir Edward Reed's abilities were of a very peculiar character. He never was in the full sense of the term a "sound" man. Whether it was that the lack of initial training told against him, or that he possessed a specially sanguine temperament, it is impossible to say. It is at all events certain that he favoured wild schemes in a very remarkable way, and that he made tremendous mistakes with a light heart. He built several small ironclads which were so top-heavy and unstable that 300 tons of ballast had to be put in each, and then they drew about 2ft. more water than they were intended to draw. It is fair to add that for much of this the Admiralty was wholly responsible. It was the practice to give numbers of people their own way, without consulting the Chief Constructor. If he designed a ship to carry 10-ton broadside guns, someone would insist that these ought to be 12-ton guns, and 12-ton guns were put in accordingly, and so on.

The Russian Admiral Popoff found in him an ardent supporter, and one who gave him material aid in the designs of the circular ironclads which were the laughing-stock of seamen and engineers alike in this country. He was indirectly responsible for the building of the Czar's yacht the Livadia, which was said to resemble a sole with a cream cheese standing on it. She cost a fabulous sum, and never, we believe, made more than a short trial trip at about 5 knots. He designed several ships with "spoon bows;" that is to say, rams, with flat spoon-like protuberances extending 10ft. or 12ft. under water, and intended to break the water up in front of the advancing hull. He designed the unfortunate Bessemer channel steamer It is impossible, indeed, to look back on his career without wondering how a man so able came to mix himself up with so many strange schemes.

The best work Sir Edward Reed did consisted in, so to speak, forcing steam propulsion down the throats of the Sea Lords and the naval veterans who were supposed to know what a British Navy ought to be. It was found that the Warrior was too long to be handy. But short ships required much power to drive them fast. Sir Edward designed the short ship, and threw himself on the engineers for speed, and not in vain. Penn, the Rennies, Maudslay, Humphrys and Tennant, and others gave him engines of unsurpassable excellence of design, material, and workmanship, and cut down the consumption of fuel from 7 lb. per indicated horse-power per hour to 5 lb., and even 4½ lb., with boiler pressures of only 30 lb. and jet condensers. Sir Edward remained on excellent terms with the engineers up to the end, but he never gave them all the credit they really deserved.

SIR EDWARD REED, K.C.B.

In private life he was genial, and in public a good speaker. He carried the British Navy successfully through a period of political storm and stress which has no parallel in the present day. He did much to transform our ships of war from the old two and three-decker into the armoured fighting machine, and for this his memory will always live in our naval annals. That he made grave mistakes is now certain; but when we bear in mind the difficulties with which he had to contend, the pressure of public opinion, the huge controversies that raged about guns, their construction, mounting, and projectiles, we can only admire the skill and talent with which he worked to an end at least as successfully as any of his contemporaries. He was a Fellow of the Royal Society, a Vice-president of the Institution of Naval Architects, and prominently associated with the Institution of Civil and Mechanical Engineers. He was a Justice of the Peace for Glamorganshire and Pembrokeshire, a Knight of Stanislaus of Russia, of the Rising Sun of Japan, and of the Medjidie, and a Commander of the Order of Francis Joseph of Austria.

CONSIDERABLE trouble has been experienced in Indiana owing to the interference of the new single-phase railways, which have recently commenced running in this district, with adjacent telephone lines. In more than one case a telephone company has found it necessary to remove its wires which run parallel to a newly completed single-phase line, and litigation is forthcoming as to whether the railway company is to bear the cost, says the *Western Electrician*. Meanwhile experiments are in progress with a view to finding a method of preventing the interference.

LITERATURE.

Elementary Principles of Continuous Current Dynamo Design. By H. M. HOBART. London: Whittaker and Co. 1906.

AFTER reading numerous books upon dynamo design which begin with a history of the evolution of the modern machine, illustrated with the well-known cuts, and filled with well-worn statements, it is a relief to take up a book like this. The author has a useful end in view, which is to help the student to design an actual dynamo, and not merely to show the reader what a clever juggler he is with the higher mathematics. We think he has in a great measure succeeded. He tells us the work is founded upon certain earlier articles and lecture notes, and, while specially suited for the student, it contains, in convenient form, matter to which the practitioner may refer.

The most useful and novel feature is undoubtedly the introduction of eighteen complete designs in tabulated form, and the student is recommended to work through them in detail. For convenience of calculation and study of these designs, tables are introduced in each chapter, giving just sufficient data of the eighteen machines to enable the student to calculate the parts of the design with which the chapter has been dealing.

The subject is treated in six chapters, and after progressing through the book and filling up the tables the student will have traversed the complete calculations for these eighteen designs. The book is suited for pupils in works as well as in colleges, and the methods of calculation are evidently deduced from actual practice. The illustrations of detail are well drawn, and different forms are shown side by side for purposes of comparison. The author has little faith in forming the pole pieces with a view to grading the "magnetic fringe," and considers it far better to design for such low reactance as to render such expedients unnecessary.

The appendix will be found very valuable, as it contains a set of tables corresponding to those occurring in the text, but with the complete calculations entered up. Design is looked upon throughout, not only with a view to obtaining the best electrical efficiency, but also from the point of view of works cost. For instance, we have a table on squared paper showing the total works costs of 250-kilowatt generators with varying armature core lengths and different armature strengths. Other tables deal, in the same graphic manner, with costs and reactance, voltages for the same machines for different speeds, and armature strengths.

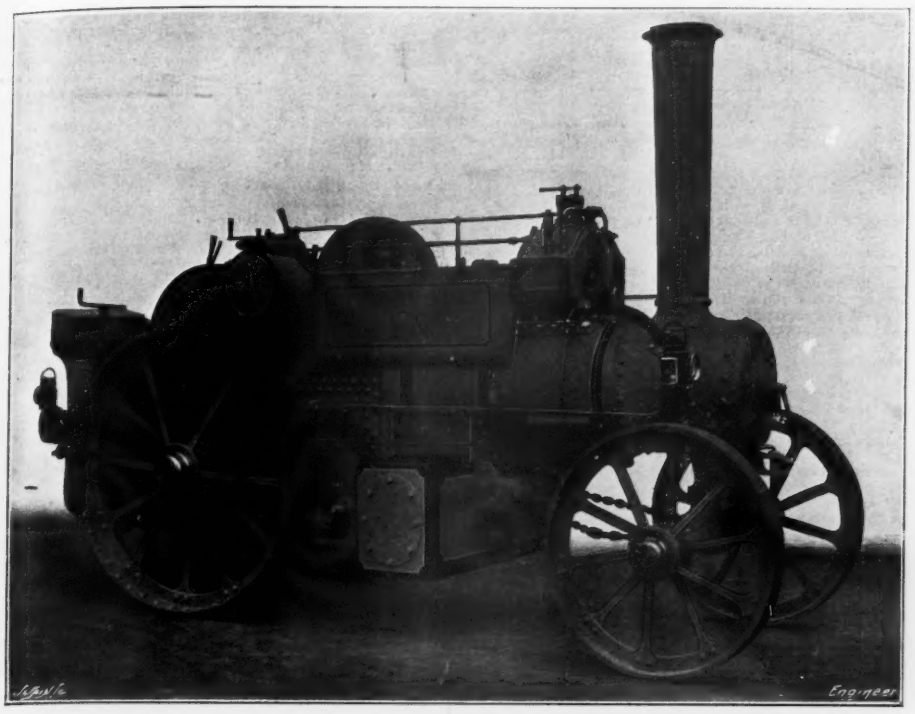
Technische Hülfsmittel zur Beförderung und Lagerung von Sammelkörper (Massengüter). Von M. Buhle. III. Theil. Fol. pp. 322, with 721 Cuts and 9 Plates. Berlin: Julius Springer. 1906.

THIS volume is the third of a series dealing with the conveyance and storage of bulk goods, including corn, coal, and minerals, and "collective bodies," if that be a proper rendering of the main title, among which are included, according to a definition on page 165, cases, bales, casks, tubs, trunks, bottles, and the like, as well as ashes, dustbin refuse, ice, &c. The appliances described include hoisting and conveyor plants of all kinds, continuous and link-belt travellers, granaries, ore-carrying steamers, sea-going dredgers, railway wagons, coal-breaking rolls, chain-grate boiler fires, hydraulic gold-mining, locomotives and wheelbarrows. Most of the subjects have been dealt with in the preceding volumes, but we gather that the present one is rather a chronicle of the later developments of the subject than part of a systematic series. The text is, in fact, a collection of papers either read before engineering societies or published in technical journals in Germany, with a few specific articles on the products of particular manufacturers. The latter are much of the character usually associated with trade catalogues, while the former being reprints without alteration from numerous different sources, where each paper has its own introduction and final peroration, there is necessarily an amount of repetition which might have been avoided by judicious revision. To any one not in a hurry the book will be interesting from the great diversity of the subjects treated and the profusion of illustrations, but to the busy man in search of specific information it may prove a little irritating, as no index is provided suited to the requirements of the casual enquirer. There is a subject indicator at the end with a certain number of catch-word headings, but as these include references to every preceding, and if we understand him rightly, some future publications of the author, its immediate utility is not large.

NEW French railway lines have been opened for traffic between Tournus and Louhans in Saône-et-Loire, between Varennes-sur-Allier and Donjon, and also between Parcoul and Riberac.

LIGHT STEAM TRACTOR

AVELING AND PORTER, LIMITED, ROCHESTER, ENGINEERS



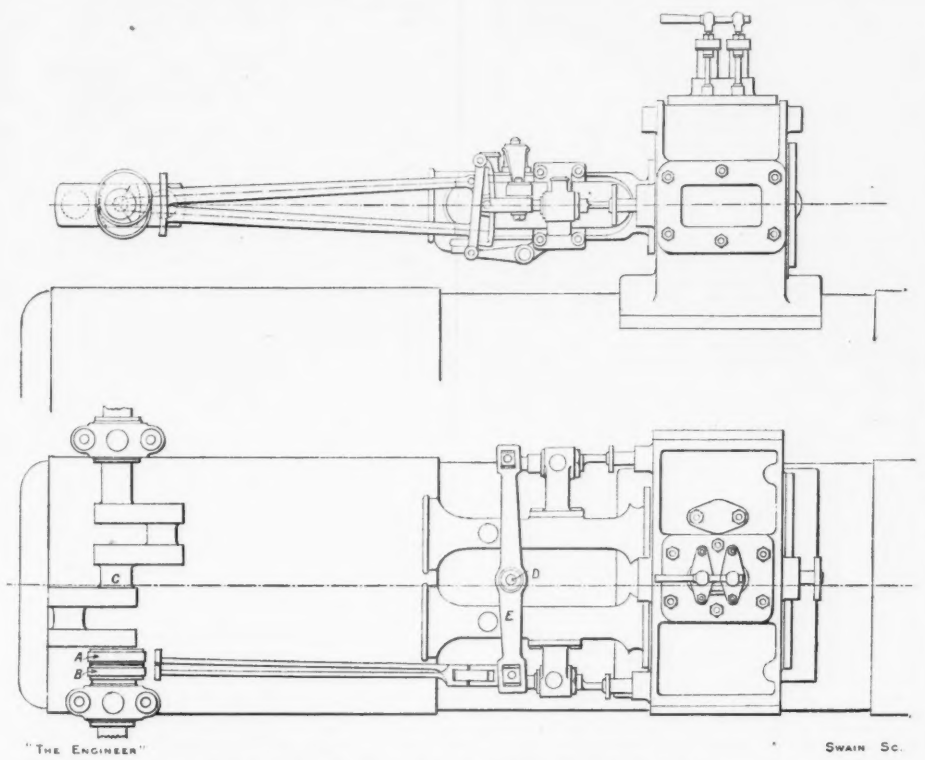
COMPOUND MOTOR TRACTOR.

THE advantages of compounding steam traction engines apply generally to light tractors which are designed to work under the Motor Car Act. The firm of Aveling and Porter, Limited, Rochester, has for some time been building engines for operating under this Act, and is now fitting a special form of valve gear, which will be on view at the Smithfield Show next week. The above illustration is a general view of the tractor and details of Neville's patented gear are given in the drawing.

The mechanism provides a simple arrangement by which the high and low-pressure valves of the cylinder can be worked by one pair of excentrics A B from the crank shaft. The high-pressure valve spindle is set in motion by means of the excentrics in the usual way. Attached to this spindle is a pin and short link which moves a rocking lever E at one end. This rocking lever works on a fulcrum bracket D fixed to the bored guides, and transmits its motion to the low-pressure valve spindle by means of another pin and slot link which is attached to the spindle at the other end of rocking shaft. The makers have supplied us with details of a recent test with one of these tractors, which speaks for itself. It is as follows :—

Weight of engine in full working order	6 tons 7 cwt.
Weight of trucks (gross)	12 tons 14 cwt.
Total load	19 tons 1 cwt.
Total distance travelled	19 miles
Time occupied on journey	5 hours
Coal consumed	886 lb.
Coal per ton mile (total load)	·92 lb.
,, ,, (useful load)	1·39 lb.
Cost of coal per ton mile (useful load)	·074d.
Water evaporated	1550 lb.
,, ,, per lb. of coal	4·61 lb.
,, ,, per ton mile	4·28 lb

The engine is provided with two road speeds, and is fitted with a pump, injector, water elevator, compensating gear, a powerful screw friction brake to each hind wheel, an additional tank under the barrel of boiler, outside valve chests to cylinders, a winding drum on driving axle, and is mounted on laminated steel springs fore and aft.



NEVILLE'S VALVE GEAR FOR COMPOUND MOTOR TRACTOR

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—A general meeting of the members of the North of England Institute of Mining and Mechanical Engineers will be held in the Wood Memorial Hall, Newcastle-upon-Tyne, at two o'clock on Saturday, December 8th. The following papers will be open for discussion:—"Practical Problems of Machine Mining," by Mr. Sam Mavor; "An Appliance for Automatically Stopping and Restarting Mine Wagons," by Professor W. Galloway; "Deposits in a Pitfall at Tanfield Lea, Tantobie, County Durham," by Dr. J. A. Smythe; "A Rateau Exhaust Steam-driven Three-phase Haulage Plant," by Mr. William Maurice. The following papers will be read or taken as read:—"Experiments Illustrative of the Inflammability of Mixtures of Coal Dust and Air," by Professor P. Phillips Bedson, D.Sc.; "Sinking through the Permian Limestone and 'Yellow Sands' by the Freezing Process," by Mr. E. Seymour Wood; "Liquid Air and its Use in Rescue Apparatus," by Mr. Otto Simons.

PROPOSED HARBOUR OF REFUGE INQUIRY.

No. I.

IN our issue of the 28th September we referred to the report recently presented to a Joint Committee of the County Councils of Devon and Cornwall by Sir William Matthews, K.C.M.G., dealing with the proposal to construct a harbour of refuge in some locality on the north coasts of Devon and Cornwall. In our leading article of the date referred to we briefly described the circumstances which have led up to the preparation of Sir William's report and summarised his principal conclusions.

We are now able to give our readers a condensed version of the report, dated June 23rd, 1906, and to reproduce several of the plans accompanying it:—

Gentlemen,—I received a letter from you dated 28th December, 1904, in which you informed me that the Sub-committee appointed by the Joint Committee of the Devon and Cornwall County Councils were desirous of engaging my services for the preparation of a report on a proposed harbour of refuge to be constructed in such position along the north coast either of Devon or Cornwall as might be considered most suitable. As a first step in the inquiry, it was suggested that I should meet the Sub-committee at Plymouth on 21st January, 1905. At the meeting referred to the nature and scope of the inquiry were considered in general terms, and it was then decided that the most promising sites for the proposed harbour were Lundy, Barnstaple Bay, Port Quin, Padstow, Newquay, and St. Ives. Subsequent study and investigation have shown that the sites referred to were the best that could have been selected, having regard to all the circumstances of the case. It was accordingly arranged that the positions named should be examined, and that I should prepare a report on the whole subject based on the following instructions, viz. :—The grounds on which a harbour of refuge is considered necessary for the coasting and fishing industries of Devon and Cornwall, including statistics of shipping, and the annual losses of lives and vessels for a period of twenty years, also the site or sites most suitable for the above purpose and the approximate cost of construction. In addition to the foregoing, it was desired that I should report—

(I.) Whether the site or sites recommended would be suitable "for the general trade of the Bristol Channel, in addition to providing for the requirements of the local coasting and fishing industries, with or without a larger expenditure than would be required for the last-mentioned needs."

(II.) "Whether the circumstances of national and local shipping are of so diverse a nature as to make it hopeless, under the circumstances, to construct any one harbour suitable for the requirements of both."

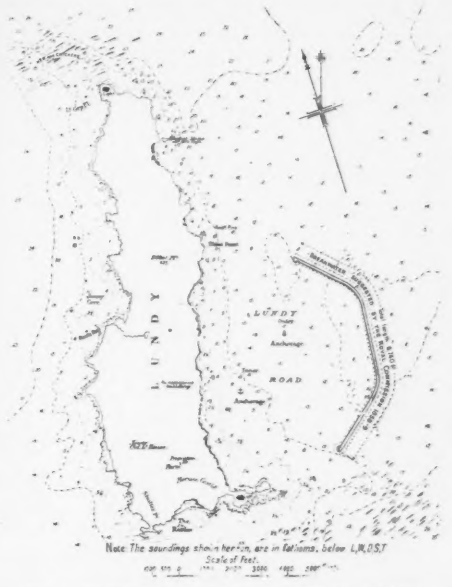


Fig. 1—SUGGESTED REFUGE AT LUNDY ISLAND

(III.) "Whether, if the cost were not a primary consideration, a site is available to meet the requirements of national shipping, as well as the coasting vessels and fishing craft of the localities concerned."

The Select Committee appointed in 1857 to inquire into the policy of making further grants of public money for the improvement of harbours of refuge recommended the extension of the harbour which at that time existed at St. Ives at a cost of £174,000, or, as an alternative, an expenditure of £35,000 at Padstow. A Royal Commission was appointed in August, 1858, which, after visiting the sites and taking evidence, prepared a Report in April, 1859, wherein it was recommended, with regard to the stretch of coast now under consideration, that a grant not exceeding £40,000 should be made for the purpose of cutting down Stepper Point, at the entrance to Padstow Harbour, with a view to create a true wind, instead of the baffling winds that prevailed in heavy north-western gales, thus preventing vessels, on some occasions, from entering the harbour with convenience and safety. The Commission pointed out, however, that as the success of the operations at Stepper Point might be considered as not entirely free from doubt, they recommended that the expenditure should be limited, in the first instance, to £20,000, for which sum the outer portion of the Point could be cut down to an extent sufficient to test the value of the entire operation for its intended purpose. On the supposition that only one harbour of refuge was necessary for the commerce and requirements of the Bristol Channel and the Land's End, the members of the Commission were of opinion that the claims of St. Ives were paramount to all others, as embracing a wider scope of usefulness, available for the general navigation of the country and of the world, and also that such a harbour, with the improvement proposed at Stepper Point, Padstow, would amply suffice for the wants of the district. Accordingly the Commission recommended that a grant not exceeding £400,000 should be made for this purpose.

A further Select Committee was appointed in 1883 to "inquire into the harbour accommodation on the coasts of the United Kingdom, having regard to the laws and arrangements under which the construction and improvement of harbours may now be effected." This Committee expressed the view, in the Report which was the outcome of their deliberations, that grants of public money might, to a limited extent, be made in aid of works which provide purely for refuge, chiefly for fishermen, on certain portions of our coast, to which a large number of boats belong, and off which great fisheries are prosecuted, while the existing harbours are only accessible to boats during a certain portion of each tide. In referring to the whole coast of Britain, they intimated "that six or eight works, carried out at an average cost of from £80,000

to £100,000, would probably meet all the requirements of the case," and mentioned the north coast of Cornwall as a district where one such work should be constructed.

In a Memorandum* prepared by Commander G. C. Frederick, R.N., of the Board of Trade, on the subject of constructing a harbour of refuge on the north coast of Devon and Cornwall, it was pointed out that from time to time the question had arisen as to the desirability of constructing such a harbour, to enable vessels to obtain shelter when caught by heavy weather on this rocky and dangerous coast, which is about 75 miles in length, and lies between Hartland Point and the Land's End. Allusion was made in this Memorandum to the configuration of the coast line being such that two bays are formed by the rocky promontory of Trevose Head, which juts out considerably to seaward, and for the purpose of discussing the most suitable position for a harbour of refuge this formation is of great importance, for should vessels be close in to the shore, or embayed during heavy onshore gales on either side of Trevose Head, there would be little chance of their being able to round it should the harbour of refuge happen to be on the farther side. Commander Frederick prepared an analysis of the wreck registers which are kept by the Marine Department of the Board of Trade. It appears from this analysis that in the twenty years under consideration—1884-1904—thirty-eight vessels were totally wrecked, with a loss of 83 lives, along the length of the coast referred to, *i.e.*, between Land's End and Hartland Point; three vessels foundered, with a loss of 35 lives; seven vessels grounded and were afterwards refloated without loss of life. These casualties might possibly, in his opinion, have been averted had a harbour of refuge existed in the locality.

Prior to the investigations in connection with the preparation of this report I had a fairly minute acquaintance with the coast between Land's End and Minehead, having been professionally connected with certain positions and visited others. Inasmuch as the data available were not sufficient to enable me to report in the sense desired and as described in the instructions, I arranged with Mr. H. T. Ker, M. Inst. C.E., and Mr. A. T. Coode, A.M Inst. C.E., to visit the sites previously named with a view to procure certain further particulars, more especially with regard to soundings, current observations, sand movements, trade and fishing statistics, the local materials available, workyard sites, and other matters affecting the designs and estimates of cost of such works as it will be necessary to refer to herein. As it was not practicable to prepare this report until I had visited the sites, I much regret that, in consequence of circumstances over which I had no control, I was unable to make these examinations until quite recently. I did not consider it necessary to visit Lundy personally, although Mr. Ker and Mr. Coode procured certain data for me there in May of last year.

The coasting traffic is now carried on chiefly in small steamers with some sailing vessels. It may be observed in this connection that the latter are being superseded by the former. The steam coaster is, of course, not so much dependent on the weather as a sailing vessel, and might possibly, in some instances, get out of a difficulty from which a sailing vessel could not escape.

The coasting cargoes are mostly coal for the mines and for household consumption. In addition to this traffic, a number of traders conveys general cargo for ports at a distance. Steamers carry from 200 tons upwards and sailing vessels from 50 to 200 tons. It would manifestly be of great advantage to these coasting craft if a harbour of refuge were provided, where they could run for shelter when caught in gales from north-west around to north-east. Danger lies chiefly between Hartland Point and Land's End. Vessels from the Bristol Channel bound around Land's End encountering heavy gales from south-west to north-west are sometimes compelled to run back to Lundy or the Bristol Channel. Steamers and sailing vessels are sometimes compelled to take refuge in St. Ives Bay when unable to weather the Land's End in strong south-west gales. Afterwards, when the wind veers to the northward, which frequently happens under such conditions, and with great rapidity, steamers, in the absence of shelter from this quarter, have to seek open water, and sailing vessels have been sometimes driven ashore, and also steamers. Vessels have occasionally found shelter in Port Quin Bay in limited numbers. At Padstow, it has been stated, as many as 135 fishing and other craft have been in the harbour for shelter at one time. It was understood at some of the meetings which I attended that a sheltered depth of from three to four fathoms at low water would be amply sufficient for the accommodation of the coasting vessels and the fishing craft. The fishing industry is deserving of the fullest consideration. The following tables have been compiled with a view to show, as far as it has been found practicable to do so, the magnitude of this industry:—

Particulars of Craft engaged in Fishing off the North Coast of Cornwall and Devon.

Fishing craft from	Description of craft.	Number.	Average value including gear.	Total value.	Average number of crew.	Total fishermen employed.
			£	£		
Brixham, &c. ..	Trawlers	200	1100	220,000	5	1000
St. Ives	1st class	80	550	44,000	7	560
,, ...	2nd class	127	210	26,670	4·5	572
,, ...	Gigs	49	80	3,920	4	196
Padstow	2nd class	24	100	2,400	3	72
Port Isaac	,,	90	127	11,430	4	360
Clovelly	,,	14	60	8 0	3	42
Newlyn	1st class	66	550	36,300	7	462
,, ...	2nd class	34	210	7,140	4·5	153
Mousehole ..	1st class	43	550	23,625	7	301
,, ..	2nd class	80	210	16,800	4·5	360
Totals ..		807		£393,125		4078

* Harbours of Refuge. Memorandum by Commander G. C. Frederick, R.N. Parliamentary Paper, Cd. 2086. 1904.

Annual Value of Fish Landed at Ports on the North Coast of Cornwall and Devon, including Newlyn.

Ports.	Year.	Value.	Total values.
		£	£
St. Ives	1905	37,000	
Padstow	1905	7 345	
Port Isaac	1905	3,356	
Clovelly	1903	1,612	
			49,313
Newlyn	1903	146,087*	
Mousehole	1903	4 329	
			150,416
Total annual value of fish landed ..			199,729

* Chiefly steam trawlers and drifters from a distance—not local boats only.

It will be observed from the foregoing tables that there are 800 craft frequenting the fishing grounds off the north coast of Cornwall and Devon, representing, with their gear, an invested capital of upwards of £390,000, and that 4000 men are engaged in the actual working of these boats. The annual value of the fish landed is approximately £200,000. The capital invested and the number of men employed in connection with the fisheries are not, of course, confined to the actual value of the fishing vessels and the men engaged in working them. The 4000 men to whom allusion has been made prosecute their calling on fishing grounds where, if caught by a north-west to north-east gale, they would find themselves off a dangerous and rocky coast and no deep water shelter to which they could run. When it is observed, on analysing the wreck statistics given in Commander Frederick's Memorandum, that the losses of fishing craft and fishermen's lives are unexpectedly small, it must not be assumed that the harbour accommodation, at present, is sufficient, but rather that the fishermen, knowing the dangers to which they are exposed, do not put to sea except under fairly promising conditions, and that they make for home when threatening weather appears. I gathered, when at St. Ives, that the mackerel fisheries are diminishing as far as the local boats are concerned, and that deep sea fishing is passing into the hands of steam trawlers and steam drifters from the east coast and elsewhere. I was informed that the local boats at St. Ives now look chiefly to the autumn and winter pilchard and herring fisheries for their means of livelihood. I understood, however, that the prospects of the mackerel fishery generally are hopeful, and that at Newlyn, where craft can enter and leave the port at low-water, considerable development may be looked for. It is only reasonable to assume that corresponding results would follow from the provision of a suitable deep-water harbour on the north coast, which would give steam trawlers and drifters an alternative harbour, their principal centre at present being Newlyn, on the south coast. The steam drifters are mainly from Lowestoft, Yarmouth, Grimsby, Hull, and Shields whilst the trawlers hail from various places, generally from Brixham and Plymouth. These last-named craft draw from 10ft. to 12ft., and are frequenting the fishing grounds off the north coast of Cornwall and Devon in increasing numbers, as is shown by the returns from Padstow of the number of trawlers entering that port to land fish, viz.:—

Year ending	Number of trawlers landing fish in Padstow Harbour.
June 30th, 1901	55
,, 1902	80
,, 1903	112
,, 1904	170
,, 1905	303
To June 9th, 1906	400

No first-class boats have been built at St. Ives for deep-sea fishing for many years. There has, however, been a considerable increase in second size boats for the autumn and winter fisheries in St. Ives Bay. The boats are nominally held by individuals, the crews working on the share system. Generally, the spring mackerel fishery off the north coast commences in February and goes on until midsummer, the pilchard fishery extends from the end of September to the end of November, and the herring fishery from October to Christmas. In Mount's Bay the pilchard fishery begins earlier, viz, about the middle of July, and continues until the end of October. Trawling is carried on, more or less, throughout the year when weather permits. The mackerel fishing in the spring extends from south of the Lizard, westward of the Scilly Islands, to the north of St. Ives. Pilchards and herring are caught in Mount's Bay and St. Ives Bay, generally within the three mile limit. Northwards of St. Ives Bay the drift fisheries diminish in importance, the number of boats and men engaged being less. Herring fishing generally is developing around the shores of Cornwall, and further accommodation is undoubtedly required. Trawling, as previously named, is extending, and fishing is now carried on as far up as the west of Lundy. Seine pilchard fishery is conducted almost entirely at St. Ives. There are indications of a revival in this industry, as pilchards visited St. Ives Bay in 1905 in larger quantities than for many previous years. I understood that the existing accommodation is sufficient for this fishery.

In connection with the establishment of a fishing centre, it is, of course, of great importance that it should be within touch of railway communication, and that suitable facilities should be afforded for landing the fish and for forwarding the same to market. On the plans attached to this report I have laid down what appears to be the minimum extent of sheltering breakwater which is required, in each case, should it be decided to provide a harbour of refuge suitable for the accommodation of large ocean-going steamers, at what may be considered the best site for the purpose, along the length of coast between the Land's End and Hartland Point.

The physical conditions which prevail along the north coast of Devon and Cornwall are certainly unfavourable for the economical construction of sheltering works of a permanent and satisfactory character. Coupled with an abnormally heavy sea — practically the full stroke of the Atlantic — there is a considerable rise of tide. Again, in some cases, there is a rock-bound configuration of the area available for shelter, whilst in others there are difficulties with regard to possible sand accumulations. The carrying out of harbour undertakings associated with such conditions must of necessity be attended with considerable expenditure, and coupled with difficulties of execution of an unusually severe character. The existing harbour works along the coast, when compared with such undertakings as would be required to provide deep-water shelter for a national harbour of refuge, or even for the lesser proposals of a coasting or fishery harbour, are entirely insignificant. Moreover, the existing works, by reason of natural protection from cliffs and headlands, are exposed to a comparatively light wave stroke when compared with the force of the sea which would fall on the deep-water structures necessary for the formation of a harbour of refuge. Again, the existing harbours at Clovelly, Newquay, and St. Ives are but of limited extent, and are dry at low water.

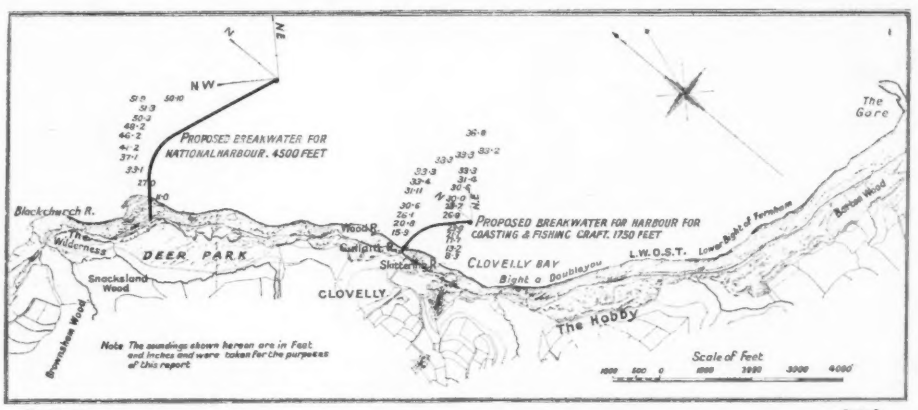


Fig. 2—PROPOSED BREAKWATERS AT CLOVELLY

SPECIAL REFERENCES TO EACH OF THE SITES EXAMINED.

Lundy Island forms a natural shelter of great value to British and foreign vessels trading to and from the Bristol Channel and South Wales ports, and is much frequented by them during south-west gales. The Royal Commission of 1859, dealing with the question of a national harbour of refuge, referred to Lundy as a site in every respect "well adapted for such a harbour, except in the important one of expense, the depth of water and consequent cost being so great as to preclude the possibility of our recommending it at present." Further on they say that the construction of such a harbour "is not to be thought of until those harbours which are of more urgent necessity shall have been completed."

I have shown in Fig. 1 the line of the breakwater, off the eastern margin of Lundy Island, as suggested by the Royal Commission of 1859. The length of this work would be 8740ft., and the cost of its construction would certainly not be less than £3,000,000. It may be noted in this last-named connection that the depth along its site is generally from 9 to 11 fathoms at low water; and as the rise of tide is 27ft. at springs, it follows that the structure would at some points be over 100ft. in height. The position of the breakwater, as suggested by the Commission, might possibly be improved by moving the work somewhat further north, in order to bring the southern approach to the harbour more under the shelter of the Island and further away from the severe tide race which is experienced there. This is a point which would doubtless receive attention hereafter should it be decided to take any active steps in the matter. Difficulties of an unusual character would be encountered in the construction of a harbour of refuge at Lundy in the absence of a suitable and convenient site for such an extensive workyard and depôt as would be required for an undertaking of this magnitude Shelter would also have to be provided, in the first instance, for the floating plant which would be necessary, *i.e.*, tugs, barges, &c.

Having regard to the enormous expenditure which would be entailed in the construction of a sheltering breakwater at Lundy of the extent contemplated in the Report of the Royal Commission of 1859, and also keeping in view the natural shelter afforded by the Island during south-west gales and the readiness with which vessels can generally leave such shelter on a change of the wind to the northward, I am of opinion that if a national harbour of refuge is to be constructed on, or in the vicinity of, the north coast of Devon or Cornwall, there are other sites where greater advantages would follow from a less expenditure, this view being generally in accord with the results arrived at by the Royal Commission, as expressed in their report of 1859. After strong blows from the south-west, the wind generally veers to the north-west, which causes a heavy sea in Barnstaple Bay. Ground swell is also experienced during the prevalence of south-west gales. When strong northerly and north-east winds prevail a "choppy" sea is likewise experienced in the bay. Sheltering works at Clovelly should, therefore, provide for protection from north-west around to north-east. At present the fishing industry at Clovelly is carried on to a limited extent only, there being about fifteen large fishing craft belonging to the port, and from twenty to twenty-five small craft; there are also four trawlers. As at St. Ives, the tendency in recent years has been to substitute small size fishing boats for the larger craft. I gathered when at Clovelly that the existing harbour there is of sufficient area to accommodate boats of the number which are now attached to the port, but as the area enclosed by the existing piers is quite dry at low water, boats running for shelter have to wait outside from three and a-half to four hours, after low water, before they can enter. Clovelly was frequently mentioned in the evidence given before the Royal Commission and the Select Committees, as having claims to be considered in connection with any proposal for a harbour of refuge along this coast. The general tenour of such evidence appears to have been based on the consideration of Clovelly as an alternative to Lundy as a site for a national harbour of refuge. No recommendation in favour of such a work for national shipping, nor for local or fishery requirements, has hitherto been made, the weight of the evidence given going to show that Clovelly is too far up Channel to be of use to the majority of vessels, and that it is too much embayed.

Fig. 2 shows a design for a national harbour, starting from the foreshore beneath Gallantry Bower, and extending therefrom in a north-east direction for a length of 1000ft., hence trending to the eastward and finishing as a straight arm in an E.S.E. direction, the total length of the work being 4500ft. The cost of such a breakwater would be £1,500,000, and it would afford sufficient shelter under all conditions, the depth under its lee being about seven fathoms at low water of spring tides. On the same plan is also indicated a smaller sheltering work starting from Gallant Rock, about 1100ft. northward of the existing harbour. It would afford protection generally from the same quarter, but to a less extent than the outer sheltering arm from Gallantry Bower. This work would be 1750ft. in length, and its cost would be £360,000; the sheltered depth enclosed would extend to four fathoms, at low water of spring tides, under the lee of the breakwater. After considering these results in conjunction with what has been stated as to the limited utility of such works, and keeping in view the extent to which, if constructed, they would be serviceable and of real advantage in affording shelter to vessels and craft in distress, I am unable to put forward either of them for practical execution.

(To be continued.)

THE PHYSICAL SOCIETY.—An exhibition of electrical, optical, and other physical apparatus will be held by the Physical Society on Friday evening, 14th inst., from 7 p.m. to 10 p.m., at the Royal College of Science, South Kensington. Invitations have been issued to members of the Institution of Electrical Engineers, and the Röntgen, Optical, and Faraday Societies. Admission will be by ticket only.

THE SHEFFIELD STUDENTS' ENGINEERING AND METALLURGICAL SOCIETY.—On the 4th inst., at the Department of Applied Science, Sheffield University, Mr. E. A. Drabble read a paper on "Bridges, Ancient and Modern," before the members of this Society. The lecture dealt with native and natural bridges, ancient and mediæval bridges, as well as with modern span bridges, comprising the principal examples of the suspension, cantilever, and arched types in England, France, Germany, and America. Upwards of seventy lantern slides were used to illustrate the lecture. One of the slides showed the old bridge which spans the river at Rotherham, and an account was given of the building which stands upon it. This building has served as a chapel or shrine, an almshouse, town gaol, dwelling-house, and shop. An edifice of a somewhat similar description is to be found at Wakefield. The lecturer concluded with a description of the swing bridge at Barton, near Manchester, which carries the Bridgwater Canal over the Manchester Ship Canal. A cordial vote of thanks was passed to the lecturer.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

LOCOMOTIVE DEVELOPMENT ON BRITISH RAILWAYS.

SIR,—Judging from the concluding paragraph of "F. A. L.'s" interesting articles under the above title, he seems to be under the pleasing impression that he has not been theorising at all. It is doubtless perfectly true to say that the estimation of the comparative advantages and disadvantages of various types of locomotives is a matter of practical experience and logical facts, but, at the same time, everything depends on the method of application of those facts. And his methods have led to some startling results, the chief being that, according to him, nearly half the power of a modern "Atlantic"—47½ per cent. to be accurate—is absorbed by the engine itself, without considering the front wind resistance.

The explanation of this lies in the fact that he assumes the percentages of resistance to increase at a rate which might be more or less plausible if applied to the actual resistances themselves, but fails to allow for the difference in power. His calculation is like a graduated income tax.

This will be easily seen if we examine some of his figures. Thus, he says, the leading wheels of *a* consume 2½ per cent. of 125 horse-power, or 3⅛ horse-power, at 25 miles per hour. The bogie of *b* takes 5 per cent. of 311, or 15½ horse-power. That of *c* takes 5 per cent. of 450, or 22½ horse-power.

Considering the advantages of a bogie, I think it unlikely that the leading resistance of *b* would amount to even double that of *a*. Suppose we accept 3⅛ for *a*, and put *b* down at 6.

Again, there is absolutely no reason that I can see for presuming that the resistance of the bogie of *c* should be 50 per cent. more than that of *b*. I will make the generous offer of 7½ horse-power for it, as it carries more weight.

Let us consider the driving wheel plus motion resistance. According to him, *a* is 25 per cent. of 125, or 31¼ horse-power, while that of *b* is 26·5 per cent. of 311, or 82·4! And we are asked to accept this in face of the fact that while the driving wheels of *a* make three revolutions, those of *b* only go round twice. That is equivalent to saying that if a similar engine to *b* were built, but with driving wheels the same size as those of *a*, the above resistance would be increased to 123 horse-power, or four times the resistance of *a*.

Again, the driving and motion resistances of *c* come to 40 per cent. of 450, or the astounding figure of 180 horse-power. If this were true, these would, indeed, be degenerate days.

This system of assuming percentages is exceedingly vague, and, though it cannot altogether be avoided, nevertheless I think, perhaps, comparisons may be drawn of some value, if we deal in the absolute resistances, and reduce them to percentages afterwards. Mr. Aspinall considers that the resistance absorbed by a modern engine is about 34 to 36 per cent. of the total power developed. In an article on train resistance in THE ENGINEER for October 2nd, 1903, when discussing a North-Western express train, the drawbar pull of which was known, I assumed the total resistance of the engine to be $\frac{8}{7}$ that of Gooch's, that being the relative diameter of the driving wheels, setting the advantages of a bogie against the objectionable coupling-rods, which led to the result of the engine absorbing, on an average, 36 per cent. of the power. As, however, the engine has more than its fair share of wind resistance, if Mr. Aspinall's opinion is to be taken as possessing any value, "F. A. L.'s" figures must be too high in all three cases.

For the sake of argument, I will allow his figure of 2½ per cent. (3⅛ horse-power) for the leading wheels of *a*. The fault here lies, I think, in his figure of 10 per cent. for the driving wheel. Without the motion, why should this be four times that of a carrying wheel? The increased friction due to the strain on the bearings is counteracted, at all events partially, by the slower rate of revolution. Taking this into consideration, I cannot allow more than 5 per cent. for them (6¼ horse-power). This makes a total wheel resistance for *a* of 10 per cent. (12½ horse-power). Agreeing to 15 per cent. for the motion, this makes the total resistance—exclusive of wind—of *a* 25 per cent., or 31¼ horse-power.

With regard to *b*, I have already declined to debit the bogie with more than 6 horse-power (2 per cent.). Comparing the driving wheels with *a*, I will take it as in direct proportion to the weights and powers, and inversely as the number of revolutions. This gives 16⅛ horse-power (5⅛ per cent.). With regard to the trailing wheels, "F. A. L." makes out they absorb 7¾ horse-power as compared with the 3⅛ of *a*. Again, I do not see why, but will allow the same as I have done for the bogie, viz., 6 horse-power (2 per cent.). This gives us 9¼ per cent. for the wheel resistance. I have accepted 15 per cent. for the motion of *a*, which is 18¾ horse-power. He is of opinion that the *b* motion accounts for 51 horse-power. Considering the speed is so much in favour of *b*, I cannot admit more than a 50 per cent. increase, and will therefore set it down as 28 horse-power, which is 9 per cent. The total of these for *b* is 56⅛ horse-power, or 18¼ per cent.

Turning to *c*, I have fixed 7½ horse-power for the bogie, and will put the trailers in at the same figure, making 15 horse-power, or 3⅛ per cent. together. For the drivers, I will first assume the whole power is transmitted through a single pair. Calculating in the same manner as before, viz., $6\frac{1}{4} \times \frac{36}{9\frac{1}{2}} \times \frac{450}{125} \times \frac{105}{12\prime}$, we have 70½ horse-power, which I should think is far too much. I doubt if it is necessary to allow any more for the fact that it is spread over two axles coupled together; however, I will throw in another 4½ horse-power, which brings it to 16⅜ per cent.

With regard to the motion, I allowed a 50 per cent. absolute increase in *b* over *a*, which fixed *b* at 28 horse-power. Making the same amount of allowance, we have 37 horse-power; but as the driving wheels are smaller, I will this time increase in the ratio of revolutions, making 45½ horse-power, or 10 per cent. Tabulating these results, we have:—

I.—*Resistance.*

	Wheels.		Motion.		Total.		
a class ..	10%	+	15%	=	25%	=	31¼ horse-power
b class ..	9¼%	+	9%	=	18¼%	=	56½ ,,
c class ..	20%	+	10%	=	30%	=	135 ,,

II.—*Horse-power Available for Traction.*

	Efficiency.	Horse-power.		Horse-power per ton weight of engine.	
a class ..	75%	.. 93¾		5	
b class ..	81¼%	.. 254¼	= +172% *b* over *a*	6·6	= +32% *b* over *a*
c class ..	70%	.. 315	= + 24% *c* over *b*	4·8	= −27% *c* over *b*
			= +228% *c* over *a*		= − 4% *c* over *a*

I must confess to a feeling of surprise that there is not a greater difference than 61 horse-power available for tractive purposes in the 8-footer and Atlantic, and fancy the resistance of the latter must be over-estimated. (No doubt the error lies in the driving-wheel resistance.) "F. A. L.," by the way, only admits to 31 horse-power difference.

I believe I have now put the figures into a shape more nearly according to facts than "F. A. L." He truly remarks that the comparisons might be extended further, into repair and running costs, which I will leave for someone else to do who has more data at hand than I possess. It is the only fair way to test his theory, which is not shared by anyone I know of, that two engines are better than one.

There is, by the way, a misprinted sign in "F. A. L.'s" paper. The +24·21 per cent., on page 519, 5in. down the centre column, should read −24·21 per cent.

December 5th. C. F. DENDY MARSHALL.

PATENT LAW REFORM.

SIR,—In your article on "Patent Law Reform," 30th November, you say:—"It was extremely satisfactory to hear from Sir Joseph Lawrence that when the deputation had represented to Mr. Lloyd George that the British manufacturers wished for the imposition of no restrictions on foreigners to which they themselves were not ready to submit, the President of the Board of Trade accepted their proposals, and promised to bring in a Bill embodying the suggested changes."

This is very nice for the manufacturers, but what about the poor inventors? From a manufacturer's point of view it is delightful, for they never endeavour to bring out an invention which they are not able to make and put on the market; but it is otherwise with inventors, thousands of whom spend all their spare time and money in working out their ideas and endeavouring to get manufacturers to take up inventions which are too costly for the inventors to work themselves.

A compulsory working clause for British inventors will, however, have other effects to those anticipated by the manufacturers. No doubt the latter think that such a clause will give them the monopoly of invention, because inventors, as a class, are too poor to work their inventions. As it is, fourteen years is a very short time to place an important invention on the market—*vide* Parsons' turbine, substantially the same to-day as when he patented it in 1884; and yet, even with an extension of that patent for five years, it had expired before he could get people to believe in it for marine propulsion.

What inventor, apart from a manufacturer, is going to bother his head about any important problem, which takes years to work out, and more years to put on the market, if he is to be limited to a working clause of three or four years? It is ludicrous, and the manufacturers who propose it are dreaming far more than any inventors. The first effect of such a clause would be to kill the inventor, to deprive the Patent-office of three-quarters of its revenue, and, incidentally, to ruin half the patent agents.

By far the majority of inventors would be only too glad to find manufacturers willing to manufacture their inventions. The trouble is that the latter will rarely do so until the patents have expired. Then they make use of them fast enough if there is anything in them.

There is scarcely one invention in a hundred which repays an inventor to-day—*vide* the patents void, owing to non-payment of annual taxes, which undoubtedly would be paid if the patent was paying. A compulsory working clause would practically reduce the life of a patent to the terms of years within which the compulsory working was applied. If a patent is worth anything at all it is worth obtaining in the countries of the union, and costs something like £200, while the annual taxes in these countries alone amount to many times this sum. The odds against the inventor now who is not a manufacturer are hundreds to one, proved by the non-payment of annual taxes. The manufacturers would make it thousands to one. Inventors will now take the former long odds, because they think that in fourteen years their perseverance will pull them through, but it is very doubtful if any will be found foolhardy enough to take the longer odds.

Watt, Stephenson, Bessemer, and hundreds of others have made England what she is to-day. Is it to be supposed that any of these men would have had the incentive and perseverance to pursue their studies and work up their inventions with a compulsory working of three or four years?

Another effect will be to drive inventive genius from the country to others, such as the United States, which offer inventors more liberal terms at a tenth the cost. To every action there is an equal and opposite reaction, and manufacturers will then find that their industries, which only prosper long under the ægis of novelty, will be left to stagnate in the slough created by individual greed, and from which their unimaginative brains will be unable to extricate them. INVENTOR.

December 4th.

[Has "Inventor" failed to notice that the suggestion is that only when an invention is worked abroad must it be worked here? If an invention is taken up by a foreign manufacturer the inventor receives his royalty on the sale in that country. We wish our correspondent was more definite as to the precise harm that would be done to the poor inventor by such a regulation.—ED. THE E.]

FLASH BOILERS.

SIR,—Your leader on "Flash Boilers," which appeared in your issue of November 30th, is at the present moment of great interest. From the numerous experiments I have carried out with this type of boiler I am led to the opinion that the water is converted into steam by a gradual process. The action of conversion is, however, so rapid, owing to the ever-advancing contact with the intense heating surface, that it justifies the term "flash" being applied to it. With the Serpollet boiler the reverse action can be watched when the relief valve comes into action, forcing the water from the coils back to the condenser, the water at first being cold and gradually getting hotter until steam appears.

Regarding the bending of the lower coils of a Serpollet boiler due to overheating, it is, in my opinion, an unfortunate condition that this type of boiler can be kept at work in regular practice with the lower coils red-hot. Not only is it unnecessary to have the coils hot, and not only does it detract from the efficiency of the boiler as a steam generator, but it actually brings about their speedy destruction, whereas with proper care, and never allowing them to get too hot, they should last for years. It must be a well-known fact that steam cannot be generated from red-hot iron. For instance, if we assume that the length of coils in a Serpollet boiler consist of 300ft., and if 150ft. of these, or the lower half next the burner, are red-hot—as they frequently are—it must be obvious that the water is all sent through them in a spheroidal state, and only converted into steam in the upper 150ft, which unfortunately is capable of supplying sufficient steam to supply the engines by forcing the burners. This condition of affairs may go on for weeks until one of the lower half of coils give way, and when a new one has to be put in, only to bring about its early destruction. The proof that red-hot coils will not generate steam can be tested by allowing the whole of the coils to get red-hot whilst running, when it will be found that the engine will stop working from want of steam. Nor can it be generated until the coils are allowed to cool down to a normal temperature.

Regarding the metal in the coils losing its nature, it is very curious that no amount of bad usage appears to make it brittle. This may be due to the process of annealing which takes place in overheating the coils. JOHN RIEKIE.

Argaith, Dumbreck, December 12th.

SIR,—In your article on "Flash Boilers," in yesterday's issue, you question why it is that "in a red-hot boiler the water does not always assume the spheroidal condition instead of sometimes." I would point out to you that there is something which you do not seem to have thought of which may account for it; that is, the intense radiant heat inside a red-hot tube of small diameter. This heat is capable of evaporating the water though it does not touch the metal, and the steam once formed is easily dried and superheated in a red-hot tube.

It is seldom, however, that such boilers are all red-hot, there is generally some point in them at the temperature at which the water will "flash" on the metal, but when working, the trouble is to know where this "priming point," as I call it, is. It may be so near the outlet that you are in danger of getting wet steam, or it may be so far back in the boiler that you presently find yourself without any steam at all. In experiments I carried out in 1898, in which I controlled the fire in such a boiler by means of a thermostat, I had to place this apparatus in series with the coils, but between the second and third one from the outlet in order to get a regulation that could be called at all satisfactory. There were ten coils in all in the make up of the boiler.

Fulham, S.W., December 1st. J. JOHNSTON.

A CENTRIFUGAL PROBLEM.

SIR,—"A. B. C.'s" letter is interesting, as it concerns a question, namely, relative motion, on which reams have been written at various times during the last two centuries and more. Without, however, plunging into the bottomless abyss of metaphysics, I should like to direct attention to the fact that the feat witnessed by "A. B. C." and his friends may be performed in two ways, one involving relative motion of the sphere and motor, and the other not involving it. For it is evident that if the sphere and motor were caused to revolve together at sufficient speed about the horizontal axis suggested, the vertical circle feat could be performed. Consequently the vertical circle can be described either with or without relative motion of sphere and motor, and it naturally follows that the centrifugal force does not depend on the relative motion of sphere and motor as between themselves, but on the motion of one or both relatively to some other body or thing. "A. B. C.'s" paradox arises from fixing attention on the relative motion of sphere and motor alone, and forgetting their motions relatively to other things. Were it otherwise, the balls of a Watt's governor would diverge if the spindle alone revolved, without carrying them round with it. Cream separators could be made to act by whirling the spindle alone, leaving the bucket and milk at rest, and anyone standing near the rim of a fly-wheel would be forcibly repelled by centrifugal force emanating from it.

Belfast, December 1st. MAURICE F. FITZGERALD.

SIR,—I think the following considerations will tend to show that "A. B. C." has arrived at a wrong conclusion. Let us take the case of a movable platform, moving at the rate of ten miles an hour. If a cyclist is riding on this platform at the rate of ten miles an hour in a direction the reverse of that in which the platform is moving, he will be stationary as regards the earth, and if transferred from the platform to the earth he would be motionless, as he would have no velocity to carry him either backwards or forwards. Now, take the case of a cyclist riding in "A. B. C.'s" rotating sphere—in the opposite direction to its movement—at such a rate that he just maintains his position at the bottom of the sphere; if the sphere were now to disappear, on touching the ground he would be stationary, as he would have no impetus to carry him either backward or forward.

If, when at the bottom of the sphere, he increased his speed till he reached the top and then reduced his speed till he was only moving at the same rate as the sphere, he would then have no velocity in relation to the earth, and, consequently, no centrifugal force to retain him in his position, and he would at once begin to descend.

I am assuming that the cyclist ceases pedalling at the moment he leaves the moving platform and when he touches the ground on the disappearance of the sphere. C. T. P.

Brighton, December 3rd.

SIR,—The problem submitted by "A. B. C." in your last issue is easily solved by examining it as shown here.

Suppose the cyclist to be inside the sphere which is rotating with sufficient velocity about a horizontal axis to keep him against the shell, while he is stationary relatively to the surface of the globe; i.e., he is moving about the axis with exactly the same angular velocity as the sphere.

If now he starts to move round the vertical great circle in a direction opposite to that in which the sphere is rotating, he will gradually reduce his actual velocity about the centre until his centrifugal force is insufficient to keep him in his path, and he falls.

I am surprised to see that "A. B. C.," or any other engineer, should fail to see that the composition of the two equal and opposite velocities would result in the destruction of the centrifugal force. A. G. H.

Glasgow, December 3rd.

THE LEVEL BOOK.

SIR,—I have tabulated the figures used by your correspondent on November 23rd according to the system I use and teach:—

	Reading.	Collimation.	Reduced level	Distance.	Remarks.
	9·25	29·25	20·00		B.M. 20 above datum
	6·50	29·25	22·75		
	5·25	29·25	24·00		
	6·00	29·25	23·25		
{	4·75	29·25	24·50	}	Change
{	10·50	35·00	24·50	}	
	5·00	35·00	30·00		
	12·75	35·00	22·25		
	14·50	35·00	20·50		
	74·50	286·25	211·75		
			74·50		
			286·25		

The blank column will be found handy in setting out for entering such things as the invert levels of sewers when fixing sight rails. I give no explanation of the system, as it is so straightforward and simple that it needs none. There is less labour, less arithmetic, less liability to error, greater facility for plotting or setting out, and more checks than in any system I know of. If your readers can put forward a better plan, I shall be glad to adopt it.

Of course, one difficulty is that all the level books, to the best of my knowledge, are ruled according to the old "rise-and-fall" method, that relic of mediævalism to which so many engineers still persist in clinging.

Queen's College, Cork. CONNEL W. L. ALEXANDER.

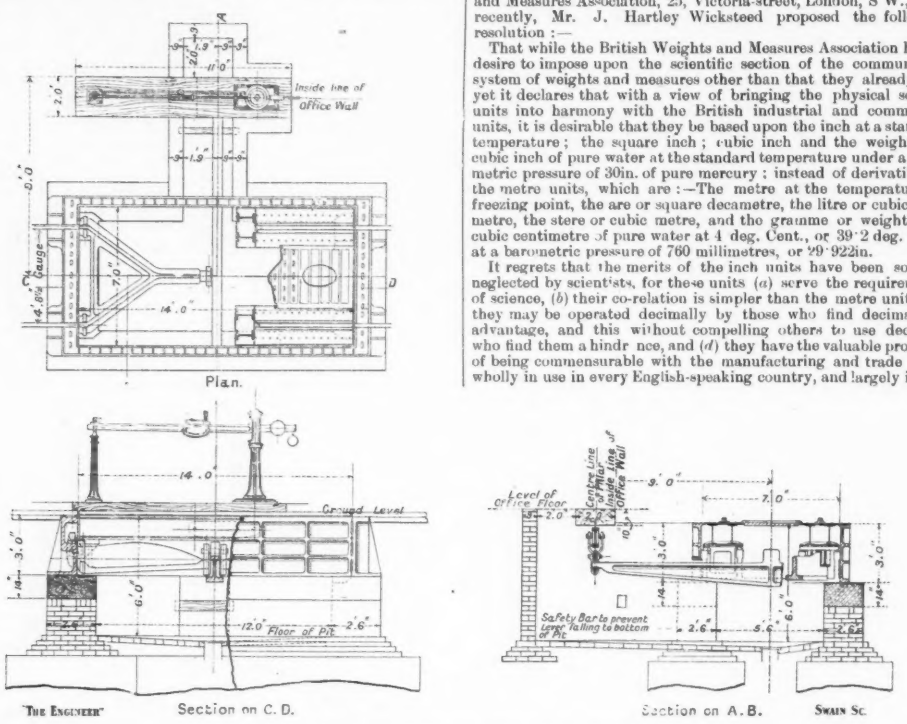
December 4th.

LEEDS UNIVERSITY ENGINEERING SOCIETY.—At the last meeting Mr. A. H. Barker delivered a lecture on "A New Method of Heating Buildings." He alluded to the difficulties heating engineers have to contend with, owing to the fact that in practice the same theoretical conditions are found to differ. Heating by direct means, such as open fires, not being suitable for large buildings or extensive or scattered areas, was left out of the question. Four heating mediums were considered—air, electricity, steam, and water. The merits and disadvantages of each were discussed, and water was shown to be the most suitable agent at present known. The defects of heating by natural circulation of hot water, or by the addition of pumps, having been pointed out, the lecturer proceeded to detail an invention known as the "Cable System," which provides automatic circulation at any desired temperature, requires no skilled or constant attention, is easy to fix at low cost, permits the necessary pipes—of small diameter—to be carried in any direction, and utilises any waste steam or other heat available. The construction and operation of the apparatus were illustrated by slides and diagrams. Particulars were also given of various installations. Various points in the lecture were discussed, and a vote of thanks to Mr. Barker concluded the proceedings.

A LARGE SINGLE WEIGHING MACHINE.

WHAT is claimed to be the largest single weighing machine yet constructed was tested recently at the Kidsgrove Works of Henry Pooley and Son, Limited, of Temple-street, Birmingham. The machine was built by this firm to the order of Cammell, Laird and Co., Limited, and is to be fitted at the entrance to that company's works at Sheffield, where, in addition to the ordinary general traffic, it will be used for weighing the heavy steel ingots manufactured there.

A general arrangement of the weighbridge is given below. It is of the maker's self-contained type, and has been designed to deal with loads up to 160 tons. The weighbridge is 14ft.

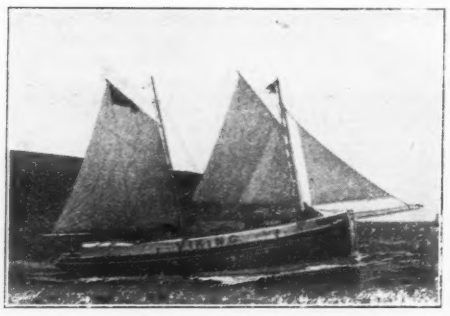


GENERAL ARRANGEMENT OF THE WEIGHING MACHINE

long by 7ft. wide, with steel rails 4ft. 8½in. gauge, The self-contained frame or box is cast with "returned ends," as shown in the engraving, to take the cast steel swinging fulcra links from which the weighing levers are suspended. This allows the full area of the rail beams to come well up to the permanent way leading on rails. The large end V weighing levers are of cast steel. The rails are bolted direct on to steel double compound girders. The steelyard, or weight indicator, registers to the full load of 160 tons without the use of loose proportional weights, The machine is designed to take the full load of 160 tons on a wheel base of 5ft. 6in. placed at any part of the weighing machine. It is said to be very sensitive, and to give readings correct to less than a pound. The accompanying engraving shows the general outline of the machine.

THE SCREW TUG VIKING.

A SMALL screw tug named the Viking has recently been built by Philip and Sons, Limited, of Dartmouth, to the order of a firm at Pernambuco, to which port, or rather to a point 150 miles south of it, she has just made the voyage successfully under sail. For convenience sake, after she had passed her steam and other trials, which, we understand, were carried out most successfully, her propeller was unshipped, and she was rigged as a schooner for the voyage out. This was necessary, as she was too small to take



THE VIKING RIGGED AS A SCHOONER

sufficient coal for steaming the distance. The following are her chief dimensions:—

Length overall	48ft.
Breadth	12ft.
Depth moulded	6ft. 3in.

Her machinery consists of a set of compound surface-condensing engines of 75 indicated horse-power, the cylinders being 8in. and 16in. in diameter and the stroke 9in. The working pressure of her boilers is 120 lb. per square inch.

With an English crew of five hands she left Dartmouth on Wednesday afternoon, September 26th last. She is believed to be the smallest vessel that has ever sailed from English shores on such a long voyage, the distance being nearly 5000 miles. Nothing was heard of her until Monday morning, November 26th, when her builders received a cablegram announcing her safe arrival on Saturday, November 24th, the voyage having lasted fifty-nine days, which gives an average of nearly 84¾ miles a day—an exceedingly good record reflecting credit not only on her builders but on those who sailed her.

Our illustration depicts the boat just as she had cast off the tug at the commencement of her long voyage.

METRIC SYSTEM.

AT a meeting of the Committee of Control of the British Weights and Measures Association, 25, Victoria-street, London, S.W., held recently, Mr. J. Hartley Wicksteed proposed the following resolution:—

That while the British Weights and Measures Association has no desire to impose upon the scientific section of the community a system of weights and measures other than that they already use, yet it declares that with a view of bringing the physical science units into harmony with the British industrial and commercial units, it is desirable that they be based upon the inch at a standard temperature; the square inch; cubic inch and the weight of a cubic inch of pure water at the standard temperature under a barometric pressure of 30in. of pure mercury: instead of derivatives of the metre units, which are:—The metre at the temperature of freezing point, the are or square decametre, the litre or cubic decimetre, the stere or cubic metre, and the gramme or weight of a cubic centimetre of pure water at 4 deg. Cent., or 39·2 deg. Fah., at a barometric pressure of 760 millimetres, or 29·922in.

It regrets that the merits of the inch units have been so long neglected by scientists, for these units (*a*) serve the requirements of science, (*b*) their co-relation is simpler than the metre units, (*c*) they may be operated decimally by those who find decimals an advantage, and this without compelling others to use decimals who find them a hindrance, and (*d*) they have the valuable property of being commensurable with the manufacturing and trade units wholly in use in every English-speaking country, and largely in use in every other country in the world, thus providing a base to which these can be easily and economically adjusted.

(*a*) Science requires weight units to be co-related through the medium of pure water with the cube of linear units. The inch units are so co-related

(*b*) It only requires a glance at the following comparisons to see how much more simply the inch units are co-related than are those based on the metre.

Inch Units (*s* equals standard inch).

s	= Linear standard
s^2	= Square standard
s^3	= Cap. and Vo. standard
s^3 weight of water	= Weight standard

Metric Units (*m* equals metre).

m	= Linear standard
$m^2 \times 100$	= Square standard
$m^3 \div 1000$	= Capacity standard
m^3	= Volume standard
$m^3 \div 1{,}000{,}000$ weight of water	= Weight standard

(*c*) All the inch standards being on a common base and not on the standard unit itself, and on decimal multiples, and sub-multiples of this unit as in the metric system, are available for binary and duodecimal multiples and sub-multiples equally with decimal multiples and sub-multiples. Thus, whilst scientists and those interested primarily in computation will use decimal multiples and sub-multiples, the foot is retained by a multiple of 12, the yard by a further multiple of 3, the chain by a multiple of 66, and so on. The engineer thereby retains his inch and foot, the ship-owner his existing draught and measurement tonnage, the textile manufacturer his yard, and the surveyor his chain and his acre. Each of these derivatives may be used as a trade unit, and decimalised exactly as they are now, for convenience of calculation.

(*d*) We see in the foregoing that whilst provision is made for scientific units which are easier of application than the metre units, this provision is based on a normal which brings those units into harmony with the existing industrial units, and whilst none of the latter are disturbed, a simple scientific base is provided to which they may be adjusted as and when manufacturers and traders find such a course desirable. For instance, one cubic inch of water weighs 252¼ grains. A very slight increase, of less than 1 per cent., to our weights would give 250 grains to an inch, and 28 inch weights to a pound. The gallon, as a vessel containing 10 lb. weight of water, would then contain 280in., whence if a decimal pint was deemed desirable, this pint would weigh 1 lb., 1 gallon 10 lb., and 10 gallons 100 lb.

Mr. Robert Kaye Gray seconded the resolution, which was unanimously carried.

CATALOGUES.

ALLIS-CHALMERS COMPANY, Milwaukee, Wis. — Photograph showing an extension of the main aisle of the works at Cincinnati.

ROBERT JENKINS AND CO., Rotherham.—This booklet describes different forms of boilers for the supply of hot water for hotels and large private houses.

J. B. HAMILTON AND CO., Unica Works, Southey-road, South Tottenham.—Circulars relating to gear wheels, gear cutting, and the "Unica" silent pinions, and also a price list of gear wheels, and pamphlet describing the "Unica" vulcanised fibre.

RICHARD HORNSBY AND SONS, Limited, Grantham.—Booklet describing the Hornsby-Stockport gas engine and suction gas plant. The following new features are embodied in this engine:—An outer bearing is supplied to the fly-wheel for all sizes above E E; the crank shaft on all engines is left long enough to take a pulley on either side; square-cut and polished crank shafts are fitted on all sizes, and the cranks are balanced by cast iron weights fixed to the crank.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Iron and Steel.

THE strong position detailed last week is well maintained. Demand continues very satisfactory in all branches, and quotations are upheld at about the levels specified last week, with here and there a few points extra being registered. At the time of writing it is anticipated that the Association standard for unmarked bars, which is nominally £7 5s., will be early advanced, thus following the example just set by Scotland, Lancashire, and Yorkshire. Sheets are in brisk inquiry at:—Singles, £8 17s. 6d. to £9; doubles, £9 to £9 2s. 6d.; and trebles, £9 12s. 6d. to £9 15s. Pig iron prices are too high for much new business. Staffordshire cinder forge is quoted 52s. 6d. to 53s 6d.; part-mine, 56s. to 58s. 6d.; best all-mine, 85s. to 90s.; Derbyshire, 56s. to 57s. 6d.; and Northamptons, 55s. to 57s. 6d. The Staveley Coal and Iron Company is said to be building two new blast furnaces capable of producing 2000 tons per week. A large output is being made of steel at good prices, the engineering trades being excellent customers for sections, for most of the engineering industries are busy and are requiring regular supplies of material, which, however, they are sometimes not able just now to obtain.

Ironworkers' Wages.

The average net selling price of iron under the Midland Iron and Steel Wages Board has been returned for the two months of September and October as £6 17s. 5d. per ton, and ironworkers' wages, therefore, continue without alteration at 8s. 9d. per ton for puddling, with millmen's wages in proportion, from December 3rd, 1906, to February 2nd, 1907. The new average is an improvement of 1s 2d. upon the previous one, but this amount is not quite enough to carry a rise in wages. The average is arrived at by an examination of the returns of sales of iron, which returns are made by seventeen selected firms. The Board's accountants are Messrs. B. Smith, Son and Wilkie, of Wolverhampton. The total output for the two months has been 37,790 tons, or an improvement of 5676 tons upon the preceding return. Bars account for 24,820 tons, or 65 per cent. of the output, and "hoops, strip, and miscellaneous" for 9968 tons, or 26 per cent. Plates and sheets amount to 2170 tons and angles and tees to 830 tons. The recently revised scale is not working out as well for them as the men expected; they were hoping for a wages advance last return, and again this return, but the figures do not yet quite justify it.

Hydraulic Engineering.

The Water Committee of the Birmingham Corporation state that the repairs to the Erdington reservoir, referred to by the Committee in their report presented on May 22nd last, have been completed, and the reservoir was brought again into use on June 14th. In the course of the work it transpired that the repairs necessary were more extensive than had been supposed, the total cost being £6274, against the contract price of £5070. During the six months to the end of September the consumption recorded throughout the district averaged 18,896 million gallons a day, against an average of 18,892 million gallons recorded during the corresponding period of 1905. Notwithstanding the extended drought during the summer the supply has been maintained without difficulty, and it has not been necessary to draw upon the upper reservoirs in the Elan Valley. There has, nevertheless, been a local scarcity in some of the districts in consequence of the demand exceeding the capacity of the existing leading mains.

The Elan Valley Works.

During the summer the works in the Elan Valley have been fully utilised for the supply in the city and district. The supply throughout has been maintained from the Caban Coch reservoir, which has in addition supplied the whole of the compensation water, consequently it was not necessary to draw at all upon the Pen-y-gareg and Craig Coch reservoirs. From the middle of August the Caban Coch reservoir filled up steadily, overflowing for the first time on October 10th. The clearing of the railways, and the disposal of plant and surplus material are proceeding satisfactorily. Most of the engineering and other officials on the construction staff have now left, and arrangements are proceeding for the transference of the works to the permanent administrative staff under Mr. Macaulay.

Harborne Tramways.

The Birmingham City Council have resolved to authorise the promotion, in the next session of Parliament, of a Bill giving powers to construct a tramway from Five Ways to Harborne, branching from the new line, which reaches the end of Islington-row from Navigation-street, to Holloway Head. This decision has not been arrived at without keen discussion. The experiment has been made of endeavouring to meet the growing needs of Harborne by improving the railway service and by the employment of motor omnibuses. The cost of the scheme will be in round figures £95,000, including street widening. Allowing for a reasonable view of the probable traffic, the new line ought to pay. The trams are carrying nearly 400,000 people every week in Birmingham now, and recently, when the Bordesley Green route was opened, some 10,000 persons were carried.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, December 5th.

An Excited Market.

THE attendance on the Manchester Iron 'Change on Tuesday was exceedingly large, and the present almost unprecedented position of pig iron caused considerable excitement. It was practically impossible to obtain reliable quotations. Hematite iron was scarce, and the price, so far as this market was concerned, prohibitive. Most, if not all, makers had withdrawn quotations, and offers must be submitted and deliveries would be as arranged. One merchant, who was in the fortunate position of having some iron to sell, dwelt on the difference between German and American methods. The first-named would haggle over 3d. per ton, while the Yankee struck in without hesitation with a dollar and bought the iron. Whether this points to a pig iron famine later on remains to be seen. Most local buyers are fairly covered forward, especially the larger people, but in some instances small consumers will undoubtedly get "left." All the agents of the makers we interviewed on Tuesday were indifferent as to selling even at the outside figures quoted. They were fully sold forward, they said. In forge iron, East Coast was 1s. 6d. to 2s. dearer, but no Lancashire was on offer.

Finished Iron.

At last the Association have made a change, and added 5s. to the price of bars, but there are opinions expressed that this figure is too small, and it will have to be followed by another 5s. at no very remote date. Indeed, outside makers are said to be asking 10s. more for forward contracts and getting it.

Steel.

Bars and billets have been advanced, as predicted in these "Notes" a fortnight or so ago. Both are fully 5s. per ton more, and for small lots even more.

Copper.

Manufactured remains steady for sheets, but tubes, in some instances, are ¼d. per lb. higher.

Quotations.

Pig iron: Lancashire No. 3 foundry, 64s.; Lincolnshire, 63s. 9d.; Staffordshire, 65s.; Derbyshire, 65s. to 66s.; Middlesbrough, open brands, 70s. 4d. to 70s. 10d. Scotch: Gartsherrie, 73s. 3d.; Glengarnock, 71s. 3d. to 72s.; Eglinton, 70s. 3d. to 71s.; Dalmellington, 70s. 3d., delivered Manchester. West Coast hematite, 77s.; East Coast ditto, 77s. to 77s. 6d., both f.o.t.; Scotch, delivered Heysham: Gartsherrie, 71s. 3d.; Glengarnock, 69s. 3d. to 70s.; Eglinton, 68s. 3d. to 69s.; Dalmellington, 68s. 3d. Delivered Preston: Gartsherrie, 72s. 3d; Glengarnock, 70s. 3d. to 71s.; Eglinton, 69s. 3d. to 70s.; Dalmellington, 69s. 3d. Finished iron: Bars, £7 10s.; hoops, £7 17s. 6d.; sheets, £8 7s. 6d. to £8 12s. 6d. Steel: Bars, £7 15s.; hoops, £7 17s. 6d. to £8; boiler plates, official, £8 12s. 6d.; plates for tank, girder, and bridge work, £7 7s. 6d.; English billets, £6 5s. to £6 15s; sheets, £8 12s. 6d. Copper: Sheets, £116 to £118; tough ingot copper, £107 10s. best selected, £108 per ton; seamless copper tubes, 14d.; brazed ditto, 13¾d.; seamless brass tubes, 10¾d. to 11d.; brazed ditto, 12d.; condenser, 12d.; brass wire, 10d.; rolled brass, 10d.; brass screwing rods, 9¾d. to 10d. per lb. Sheet lead, £22 5s. per ton. Tin: English ingot, £196 10s. to £197 10s. per ton.

Lancashire Coal Trade.

A safe indication of the good trade prevailing is the fact that full time is being worked at the pits. On the Manchester Coal Exchange on Tuesday there was scarcely the usual large attendance, but a very good demand was again reported for engine fuel and slack generally. Coal for shipping was the turn dearer. Best coal for domestic purposes, 14s. to 15s.; seconds, 13s. to 13s. 6d.; common, 9s. 6d. to 10s 6d.; best round engine fuel, 8s.; best slack, 7s. to 7s. 6d.; medium, 6s. 6d. to 7s.; common, 5s. 6d. to 6s. at the pit.

BARROW-IN-FURNESS, December 6th.

Hematites.

The hematite pig iron trade remains very strong, and the market is active and vigorous; indeed, there are increasing indications that a famine in steel-making iron will soon be with us, as the demand is greater than makers can deal with, and they are not in a position materially to increase their output. This may be done in isolated cases, but the difficulty in the way is chiefly one of blast, makers, generally speaking, having all they can do to supply their furnaces with the heavier blast which is now the rule in the district, and which is essential to the economic production of iron under modern blast furnace practice. In the case of the Barrow Steel Company, it is putting down plant to increase its blast very materially, but this will not be accomplished for a twelvemonth yet, and in the meantime much of the trade now being done will possibly evaporate or be transferred to other districts where hematite iron is made. Makers are running 39 furnaces, and the yield of metal is very large They are well sold forward. Stocks have decreased 1545 tons, and now total at 77,455 tons, of which 55,955 tons are held in Furness. Makers still quote 77s. per ton net f.o.b. Warrant iron is practically at 76s. per ton net cash sellers. Iron ore is higher at 17s. 6d. per ton, and foreign ores are at 21s. net at West Coast ports.

Steel Trade.

The steel trade of the district is, remarkable to say, depressed. Orders for rails are especially few, and the market is likely to be quiet for some time, now that prices have advanced to £6 10s. for heavy sections net f.o.b. In shipbuilding steel the market is not brisk, and prices here again have advanced to £7 10s. net cash. Merchant steel is quiet. Steel foundries are only moderately employed. The mills at Barrow are stopped this week, but makers of iron find it better to sell their iron at present prices rather than make it into steel.

Shipbuilding and Engineering.

Shipbuilders are very short of orders, but are in negotiation for some large vessels. Marine engineers have plenty of work, and in the gun-mounting department they are especially full of orders. An arbitration case, under Sir William Matthews, between the Corporation of Barrow and the Furness Railway Company has been concluded in London, after a six days' sitting, as to the length of dolphins to be constructed in connection with Walney Bridge. The Corporation, in Sir Benjamin Baker's plan, propose to construct dolphins, 50ft. in length, on each side of the bridge opening, and the Furness Railway Company wants these dolphins to be 400ft. long on the south side and 200ft. on the north. The difference in cost will be about £52,500. Sir William Matthews has now to give his decision.

Shipping and Coal.

The shipping trade is quieter. The aggregate shipments this year have reached 75,209 tons, being a decrease of 9434 tons on the corresponding period of last year. A brisk business is being done in coal and coke at improving prices.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Iron Market: Further Advances.

AGAIN we have to report an advance in iron. Last week there was recorded an increase of 1s. 6d. per ton by the Lincolnshire Ironmasters' Association, raising the quotations to the highest point then attained for the year. This week a further advance of 1s. per ton has to be noted, bringing the official quotations up to the following figures:—Lincolnshire, No. 3 foundry, 61s. per ton; No. 4 foundry, 59s. per ton; No. 4 forge, 58s. per ton; No. 5 forge, mottled, white, and basic, 61s. 6d. per ton. Even at these quotations there is no eagerness shown for business; makers being generally sold forward for months, and there being confident expectations of still higher prices ruling next year. Derbyshire makers retain the figures already given—No. 3 foundry, 60s. per ton; No. 4 forge, 57s. per ton—but these are nominal quotations, there being few transactions, owing to stocks being sold forward. Bars and sheets are 5s. a ton higher than last week. Bars, £7 15s. to £8 per ton; sheets, £9 5s. to £9 15s. per ton. In hematites West Coast are quoted at the time of writing 85s. 6d. to 86s. 6d. per ton, less 2½ per cent., delivered at Sheffield and Rotherham; East Coast, 83s. to 83s. 6d. per ton net. The heavy demand for irons for the United States and Germany, with increased requirements at home, explains the present situation.

Steam Coal and Railway Contracts.

Although the higher ports in the Baltic are now closed for the season, a very good business is still being done with the lower ports, which remain open, and shipments keep well up. The weight exported from the Humber for the week ended 27th November was 54,686 tons, compared with 22,777 tons for the corresponding week of last year; from Grimsby, 30,223 tons, compared with 29,704 tons. Railway coal contracts remain in negotiation. The coalowners' offer of 9s. 6d. per ton for supplies for 1907 has not been accepted, but an offer of 9s. per ton has been made. The coalowners have, in turn, refused this offer. The companies chiefly concerned are the North-Eastern and Great Central. The Furness Railway Company—not, of course, such a large buyer as the others—has contracted at 9s. 7½d. per ton, plus 2 cwt. per wagon.

House Coal.

The comparatively mild weather keeps demand unsettled, but a very fair business is being done. Higher grade coals are again in more request, some stocks which had accummulated having been practically cleared. Heavier tonnages are being sent to London, and the southern, and eastern counties markets. Prices are not materially altered. Good Silkstone, which is scarce, fetches up to 12s. 6d. per ton, secondary sorts from 10s. to 10s. 6d. per ton. Best Barnsley thick seam coal is quoted up to 10s. 6d. per ton, other qualities about 9s. to 9s. 3d. per ton at the pits.

Coke, Slack and Smudge.

Continued briskness is reported in coke, slack, and smudge, owing mainly to the large and increasing requirements of the patent coke ovens. Good samples fetch up to 4s. 9d. per ton. Manufacturing fuel, which is sent chiefly to the Lancashire and Yorkshire textile districts, is about 3s. 6d. to 3s. 9d. per ton at the pits. Coke, mostly the product of the patent ovens, is being forwarded in heavy weights to North Lincolnshire, and a considerable tonnage is also being sent to Derbyshire, Leicestershire, and Nottinghamshire melting districts. Values are rising, unwashed coke being now quoted at from 12s. 9d. to 13s. 6d., washed coke from 13s. 6d. to 14s. 6d. per ton.

Stee .

Extreme activity marks the leading departments of the steel industry. For high-speed special steels the call is more than maintained both for home and foreign markets. The principal makers are producing largely for the Continent, as well as for the United States and Canada. Ordinary tool steels are also in brisk request, and the railway material departments being busy the steels used in that branch are in heavy demand. More is reported to be doing in castings for hydraulic and electrical machinery, as well as for motor manufacture, the latter a feature of local production which is being rapidly developed this season, and is certain to become increasingly important.

Engineering Work, &c.

Satisfactory reports are received respecting work in hand at the various establishments in Sheffield and district. The continuous extensions in the large works, and the enterprise shown in the application of the latest appliances and most up-to-date machinery, bring orders to engineering firms in nearly all departments. A good deal of work for constructive purposes, both for home and export, in bridge and roofing, is keeping several Derbyshire firms busy in these departments. Makers of colliery and engineers' stores are full of work, but complaint is heard of keen competition keeping prices low. Firms which make a speciality of twist drills, milling cutters, and similar tools are busy, and pressure is reported in the call for files, which are being freely ordered. Engineers' tools, in most of the leading departments, are in satisfactory request, with every prospect of good business extending well into the New Year.

Silver, Plated Ware, Cutlery, &c.

The improvement in business which set in about a couple of months ago, largely, of course, on season trade, has been maintained. A satisfactory feature of the revival is that it applies to most of the important markets both at home and abroad. Even South Africa, which has been dull for a long time, is showing signs of recovery, some fairly good orders having recently been received. More is also being done with Canada, which, like the United States, has a preference for the higher qualities of the wares it takes from the Sheffield workshops. The Americans, although they do not order from us largely in the class of goods for which there is the greatest sale, are excellent customers for the superior grades of Sheffield cutlery. The general improvement in foreign demand for cutlery, indeed, is chiefly in respect of the finer goods, and recent orders for several Eastern markets have exhibited a similar desire for the higher qualities.

Sheffield Chamber of Commerce.

On the subject of "The Australian Commerce Act," a letter was read at the Council meeting of the Sheffield Chamber this week, from the Australian Agency in London, stating that no specific form of trade description is required on goods imported into Australia, except with regard to wearing apparel, food, manures, and jewellery. As to other goods, the only restriction is that if any description is put upon them it shall not be false. This will remove a wrong impression which had obtained that all goods imported into Australia should be marked. A letter was also read from the Commercial Department of the Board of Trade, intimating that the United Kingdom is entitled by treaty to the most favoured nation treatment in Servia, and consequently obtained the advantage of tariff reductions which have been conceded to Germany under the recent Servian and German Treaty.

Dearness of Materials.

Values of raw materials used in several of the lighter staple industries have been rising rapidly during recent months. For example, standard copper in London, now quoted about £104, lifts refined B.S. metal delivered in Sheffield to nearly £112 per ton, which is £25 per ton over the maximum figure reached. In hafting materials, such as ivory and horn, the conditions which have ruled for some time now exhibit about equal disadvantages for the trades concerned. The enormous advances in ivory suitable for the Sheffield trades have been repeatedly noticed in our trade reports. At the London quarterly horn sales on the 30th ult. there were sold 80 tons out of the 110 tons East Indian deer horns offered. The supply was slightly in excess of the weight offered in August, and there was a good demand. Sheffield houses were well represented.

NORTH OF ENGLAND.

(From our own Correspondent.)

Strong Improvement in Trade.

THAT there is in the iron and steel industries a "boom" in progress of a very pronounced character becomes every day more apparent, and this week the activity of business has been exceptionally strong. Consumers recognise that the time is over for waiting, and that they must buy without delay. It is generally believed that good as trade has been this year, it will be even better in 1907; indeed, that is almost guaranteed for the first half. Those, therefore, who continue to hold off in the expectation that easier prices may ensue within the next few weeks are not likely to find themselves able to purchase on more advantageous terms than the present. That being so, consumers are much keener than sellers to do business, and they would buy freely for forward delivery at present rates if makers were prepared to commit themselves further ahead. As a matter of fact, the ironmasters in this district have very little iron unsold for delivery over the first two or three months of next year. They mostly have filled their order books for that period, though at figures below those which have recently prevailed, a circumstance which some of them rather regret. It is calculated that they have this year increased their production of pig iron by 300,000 tons, yet the present output is not equal to the requirements, and the withdrawals from the stock in the public stores increase. Nearly every existing furnace in the North-East of England which can be utilised is in operation. The difficulty of getting larger supplies of materials is great, and makers are prospecting all over the district for further deposits of ironstone, and are utilising seams which in the past no one would look at, owing to their thinness and the poor quality of the ore. The ironstone in the Commondale valley is to be opened up, as are several deposits in the neighbourhood of Ayton, Grosmont, Kildale, and Kettleness, all on the outer edge of the great Cleveland ironstone field.

American Demands for Pig Iron.

American consumers continue to buy Cleveland iron, and it is estimated that there are at the present time orders for nearly a quarter of a million tons on the books of Cleveland makers for execution on American account. The rapid rise in prices does not appear to have checked the business, and advices from the United States note that Cleveland iron will probably, at an early date, find its way, not to the Eastern States alone, but also to the Middle and Western States. Hitherto, all that has been sent or sold has been for delivery in the Eastern States, in districts not far from the seaboard.

Cleveland Pig Iron.

Some difficulty has been experienced this week in buying Cleveland pig iron from the makers, because they have so little to sell for delivery during the first quarter of next year. Most of the orders which they have on their books are reported to have been secured when 55s. was being quoted for No. 3, and thus they are prevented from reaping the full benefit of the present rise. This week they have advanced their quotation for No. 3 Cleveland G.M.B. pig iron to 63s. 9d.; No. 1 is up to 65s. 3d.; No. 2 foundry, to 62s. 3d.; and No. 4 foundry to 61s. 3d. Mottled and white continue unobtainable and are not quoted.

Hematite Pig Iron.

The prices of East Coast hematite pig iron are going up even more rapidly than Cleveland iron, and there is warrant for this, because it is increase in legitimate demand and not speculation that has been the reason for the rise. There is no doubt that there is a substantial improvement in all the branches of the steel trade that are consumers of hematite iron. There is no stock in makers' hands and none in the public stores, while the production actually falls short of the requirements. The reports about the shipbuilding industry likewise have become considerably more encouraging. There is a good foreign demand for our hematite iron. Sellers have put up the price of mixed numbers to 76s. 6d. per ton, whereas a short time ago they had to be content with 68s. Rubio has been raised to 23s. per ton c.i.f. Middlesbrough, and medium coke to 21s. delivered at the furnaces in Middlesbrough; indeed, some coalowners have got 21s. 6d., and in certain cases much more where delivery was guaranteed in the forthcoming holidays.

Stock of Pig Iron.

There is no stock of hematite iron in this district, either with makers or in the warrant stores, while producers are likewise almost cleared of Cleveland pig iron. The stock of Cleveland iron in Connal's public stores was heavily drawn upon last month, a decrease of 27,523 tons having to be reported, against 21,480 tons in October. Since March the stock has decreased 200,143 tons, or over 30 per cent., and the quantity at November 30th was 549,952 tons, of which 531,429 tons were No. 3, and 18,523 tons No. 4 foundry.

Exports of Pig Iron.

The shipments of pig iron from the Cleveland district were remarkably good—in fact, the best of any month on record—a result which was hardly looked for, especially as the month was a short one. The quantity was 144,741 tons, and this represents a shipment per working day of 5566 tons, as compared with 5325 tons in October, and only 2950 tons in November, 1905. More would have been exported if the shipping facilities at some of the wharves had been more efficient. It took the produce of 46 of the 65 furnaces in operation in the Cleveland district to satisfy the export requirements last month. In November last year 77,503 tons were exported, or 87 per cent. less than last month, and in November, 1904, the quantity was 67,238 tons only. Last month Middlesbrough shipped two-thirds of all the pig iron that went oversea from the United Kingdom. There were very large increases in the deliveries to Germany, Italy, America, Belgium, and France. Germany took 37,145 tons, and America 33,040 tons.

Manufactured Iron and Steel.

There has been a pretty general advance of prices this week in the manufactured iron and steel industries, due partly to the better demand, and partly to the greater cost of production, all raw materials being dearer. Last week a 5s. advance in bars was announced, this week there has been a second advance of equal amount, so that common iron bars are now at £7 15s.; best bars at £8 5s.; and best best at £8 15s., all less 2½ per cent. f.o.t. On Monday the Scotch bar makers put up their prices 10s. per ton to £7 17s. 6d., less 5 per cent., so that the quotations in the two districts are practicaly identical. On Wednesday afternoon the platemakers in the North of England had a meeting at Darlington, and decided to advance prices 5s. per ton, the first change that has been made in their quotations since October of last year. Steel ship angles are put up this week to £6 17s. 6d., and steel joists to £5 12s. 6d., both less 2½ per cent. f.o.t. Iron ship plates are up to £7 10s., less 2½ per cent. Heavy steel rails have gone up to £6 10s. net, and cast iron chairs to £4 2s. 6d. net. Pipes are also 5s. dearer. Thus practically all prices of manufactured iron and steel have been advanced during the last fortnight.

The Strike at the Tees Shipyards.

The strike of the platers at the shipyards on the Tees and at the Hartlepools, which has been in progress for five weeks, and which has thrown idle a large number of other workmen, will probably be ended by the time this appears in print, as a further conference is arranged, and the men have drawn up proposals which will doubtless find favour with the employers. The particulars, however, are not yet made known.

Shipbuilding and Engineering.

Indications of revival are apparent in the shipbuilding industry, notwithstanding that freights are very little better, and it would seem that there are already too many vessels offering for the commerce that is reported. Nevertheless there is no doubt that the world's trade is growing rapidly, and there seems to be better times in store for the shipowners. One indication of the improvement is the booking of heavy orders for material. Orders for tramp steamers, which were getting very scarce, are increasing, and there is a report that fully thirty new boats have lately been ordered in this district. There is no doubt about the change for the better which has taken place. In the engineering and bridge building trades there has been some improvement.

Coal and Coke.

The demand for coal is most active; indeed, it is probable that it was never better than it now is. The collieries are kept in the fullest operation, and sellers have put up prices. Best steam coals are advanced to 11s. 9d. per ton, seconds to 10s. 6d., and smalls to 7s. 6d., while best gas coals are at 11s. and seconds at 10s. The demand for bunkers is strong, and the price has gone up to 10s. 9d. per ton. Coking coal realises 11s. to 11s. 6d. per ton. Coke is scarce, and the sellers are securing 21s. per ton for deliveries of medium qualities to be made over next half-year. The decision of the Durham miners to abolish the Conciliation Board which has been in operation for the last fourteen years for adjusting wages is generally regretted, but the last word on the matter has not yet been said, for the ultimate decision will rest not with the miners alone but with the Durham Federation, which comprises the Enginemen's, the Cokemen's, and the Mechanics' Associations, as well as that of the miners. The meeting of the miners on Saturday decreed the abolition of the board, but it was only by a narrow majority. They are dissatisfied because the advances of wages lately have been less than they considered they ought to have been.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General State of Trade.

THE position of business generally is perhaps a little more encouraging, but there is evidently still room for improvement. The great activity in the iron trade has a certain influence on other industries. No doubt activity in such an important industry indirectly helps others; but there is at the same time this disadvantage, that the iron is mostly required for abroad, and the extreme demand has abnormally raised prices of raw material against the home consumer, who has not been able to obtain a corresponding advance in the articles of his manufacture. Business in this respect is hampered to a considerable extent, and the great rise in prices of pig iron has not brought out fresh orders for manufacturers to anything like the extent that has been experienced in some former times of high pig iron values.

Foreign Demand for Pig Iron.

The inquiries that come from America for supplies of pig iron have, since last report, continued to stimulate the market in an extraordinary degree. Each day brings its crop of rumours on 'Change as to fresh demands, actual or probable. Those who watch the market carefully, and read the newspaper reports on the subject can see that the reported inquiries are immensely in excess of the business really done, and also that transactions are apt to be reported over and over again in different forms. But after making allowance for these inaccuracies, which occur in most times of excited markets, the orders secured are such that iron-masters find their resources taxed to the utmost to cope with them. Within the last few days some heavy orders are reported to have been put through on American account. Considerable business is also noted on behalf of Canada, while home consumers have been larger purchasers.

Prices of Scotch Makers' Iron.

The prices of Scotch makers' pig iron were all further advanced at the end of last week in amounts varying from 6d. to 2s. per ton, which gave the following rates:—G.M.B., No. 1, was quoted at Glasgow 68s. 6d.; No. 3, 68s.; Govan and Monkland, Nos. 1, 69s. 6d.; Nos. 3, 67s.; Carnbroe, No. 1, 71s.; No. 3, 68s.; Clyde, No. 1, 72s. 6d.; No. 3, 67s. 6d.; Gartsherrie and Calder, Nos. 1, 73s.; Nos. 3, 68s.; Langloan, No. 1, 73s.; No. 3, 68s.; Summerlee, No. 1, 75s.; No. 3, 70s.; Coltness, No. 1, 83s. 6d.; No. 3, 68s. 6d.; Glengarnock, at Ardrossan, No. 1 74s.; No. 3, 69s.; Eglinton, at Ardrossan or Troon, No. 1, 69s. 6d.; No. 3, 66s. 6d.; Dalmellington, at Ayr, No. 1, 71s.; No. 3, 66s. 6d.; Shotts, at Leith, No. 1, 72s. 6d.; No. 3, 68s.; Carron, at Grangemouth, No. 1, 75s.; No. 3, 70s. per ton. Since the above figures were obtained, it is right to state the market has become considerably stronger, and it is reported on 'Change that some makers have been asking a further advance of 2s. to 3s. per ton.

The Pig Iron Output and Stocks.

There are ninety furnaces in blast in Scotland, of which forty-four are making ordinary and forty hematite, while six continue to turn out basic iron at Glengarnock. In past weeks furnaces were gradually transferred from hematite to ordinary iron, as the foreign demand for the latter increased, but it is now found practically impossible to proceed further in this direction, owing to the improved demand for hematite. The makers can, therefore, only keep the furnaces running as much as possible under conditions that will enable them to obtain the maximum output. Regarding the makers' private stocks no reliable information is obtainable, but it is understood that they are being materially reduced. Official returns will be obtained as to their amount at the beginning of January. The stock of pig iron in Glasgow warrant stores was reduced in the course of the past week 1392 tons, bringing the total down to 12,886 tons, of which 8386 was ordinary and 4500 tons standard foundry pigs.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week amounted to 9478 tons, compared with 5732 in the same week of 1905. Total shipments to date reach 311,075 tons, being 34,794 tons more than in the corresponding period of last year. The arrivals of Cleveland pig iron at Grangemouth were 8656 tons, being 83 tons less than in the corresponding week. The total arrivals for the eleven months are 473,951 tons, an increase of 23,626 over the imports in the same period of 1905.

The Warrant Market.

There has been a large turnover in the pig iron warrant market, which has been generally strong, and at times much excited. Prices have fluctuated partly owing to the demand, and also, it is alleged, to a considerable extent, on account of speculative commitments. The high price of money has tended to repress speculation, else the market would experience even greater excitement and increased transactions. In the last day or two business has been done in Cleveland warrants from 61s. 8d. to 63s. 3d. cash, 62s. 7½d. to 63s. 9½d. one month, and 63s. 3½d. to 64s. three months' delivery. Scotch warrants have been at 66s. to 66s. 6d., and standard foundry iron 61s. 1½d. to 62s. 1½d. per ton.

Hematite Pig Iron.

There has been in the last few days a material increase in the demand for hematite pig iron both on home and export account. From America the inquiries have become more urgent, and both Cumberland and Scotch iron are in request. Cumberland warrant iron has advanced in the last fortnight from 70s. 9d. to 77s. cash business done, and 76s. 9d. has been paid for delivery in one month. Merchants have been quoting Scotch hematite in the same time from 72s. 6d. to 77s., and at the time of writing the price is said to be almost 80s. per ton. The demand for West Coast and Scotch hematite, in any large volume, has sprung up only within the last two or three weeks, and it will be observed from the above figures that the rise of price in that time has been quite phenomenal.

Finished Iron.

An improvement has to be noted in this department, the home and shipping inquiry being alike more active. In consequence of the constant advance in raw material, the Scotch makers were obliged a few days ago to raise their prices 10s. per ton, bringing up the price of unbranded iron to £7 15s., and the basis prices of crown bars to £7 17s. 6d, steel bars being £8 per ton, all subject to the usual 5 per cent discount. Since these rates were arranged, pig iron has gone higher, and this will no doubt lead to further advances in manufactured articles.

The Steel Trade.

The makers of steel have been feeling some improvement, but in the last few weeks work had been a little irregular. The policy has been, as far as possible, to arrange prices so as to encourage business orders, and not to keep them back. The makers have accordingly been acting with caution in the matter of quotations, which ought to be considerably higher than those now current, to make up for the great rise in pig iron. Present appearances seem to point to decided improvement in demand. The inquiry for structural material for abroad is very encouraging.

Sheets, Hoops, and Strips.

There is increasing demand for these articles, and the prices of strips have been advanced 10s. to 12s 6d. and hoops 12s. 6d. per ton. Sheets have also been raised, black sheets 5s. per ton. It is reported that great activity exists both in the galvanising and black sheet trades. Makers of these are said to have work in hand that will keep them going for months.

The Coal Trade.

The past week's coal shipments have been heavy, and the home demand is more active. In consequence of colder weather, the household demand has improved, and there is also more business doing in coal for manufacturing purposes, some qualities of coal being advanced 6d. to 1s. per ton for present month's deliveries.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Improved Value of Welsh Coal.

IN the closing days of the year, when taking a retrospective glance at the quantities worked and prices realised of the coal for 1906, it is evident that Welsh coal has advanced in trading estimation. Statisticians, who are now busily at work preparing totals, say that the output of the year has been larger and well maintained, without any of those serious breaks which have occurred in years of strikes; and, further, that the export has been larger. Taking fair averages, it is shown that prices have been from 2s. 6d. to 3s. 6d. above the prices of December, 1905.

Present State of the Coal, Coke, and Patent Fuel Trade.

I have again to report a busy week. The exports from the Bristol Channel ports last week showed an increase of some 7000 tons over that of the corresponding week of last year. This increase was mainly due to increased activity at Swansea, that port indicating an improvement of some 20,000 tons; Cardiff and Newport had 13,000 tons each increase. Swansea continues to benefit by a large trade with France. Last week Rouen took thirteen cargoes, St. Nazaire 5000 tons. North French and Bay of Biscay continue the leading customers. Cardiff, on the other hand, is doing largely with the River Plate. Eleven cargoes went last week with 39,000 tons; Port Said took six cargoes with 30,000: Rio Janeiro three with 14,000. North French demands are also strong at Cardiff. Calais took four cargoes with 10,000 tons, and Havre eight with 13,000. At Newport, in the matter of bulk, there has not been any cause of complaining, the clearance last week having been within a shade of 90,000 tons, Genoa taking three cargoes with 8800, Gibraltar six cargoes with over 7000 tons. Coastwise totals were nearly 18,000 tons. In coke a fair amount of business is being done due to the activity in the iron and steel trades, and prices continue firm, furnace qualities realising from 17s. to 18s., foundry from 22s. to 23s., ordinary qualities, while special were quoted, on 'Change, this week, at 28s. to 30s. In patent fuel all ports are busy. Swansea last week despatched 12,595 tons. Cardiff exported 5000 tons to Vera Cruz, and Newport 3000 tons to the same port.

The Coal Market: Latest Quotations.

There is an intimate connection between the weather and the market. Given clear, bracing weather, with improved tonnage, there would not be the easiness in price that is occasionally shown. Prices, on the whole, have ruled steady, but arrivals of tonnage have been delayed by bad weather, with the result that many of the collieries have been badly off for empties, and this has caused some to take lower prices for spot shipment, in order to release the laden wagons. For backward shipment there appears a good inquiry, and prices are well maintained. Small steam are, if anything, slightly lower; best Cardiff and Monmouthshire large, steady. On 'Change, Cardiff, this week quotations were as follows:—Best steam, 15s. 6d. to 16s.; best seconds, 15s. to 15s. 6d.; seconds, 14s. 6d. to 14s. 9d.; drys, 14s. to 14s. 6d.; best washed nuts, 12s. 6d. to 13s.; seconds, 11s. 6d. to 12s.; peas, 11s. 6d. to 11s. 9d.; seconds, 10s. 6d. to 10s. 9d.; best smalls, 9s. to 9s. 6d.; best ordinaries, 8s. to 8s 6d.; seconds, 7s. 3d. to 7s. 9d.; inferiors, 6s. 3d. to 6s. 9d. Monmouthshire semi-bituminous: Best large, 14s. 3d. to 14s. 6d.; best ordinaries, 14s. to 14s. 3d.; seconds, 12s. 9d. to 13s. 3d.; inferiors, 12s. to 12s. 6d. House coal, best, 16s. to 16s. 6d.: best ordinaries, 13s. 6d. to 14s. 6d.; seconds and other kinds, 11s. to 13s.; No. 3 Rhondda, 16s.; brush, 13s. 3d.; smalls, 11s. to 11s. 3d.; No. 2 Rhondda, 12s. 3d. to 12s. 6d.; through, 9s. 6d. to 10s.; smalls, 7s. 6d. to 8s. Patent fuel, 15s. 3d. to 15s. 6d.

Pitwood.

Prices continue high, but not so high as they have been, as much as 30s. having, it is said, been quoted. This week 25s. is the prevailing figure. For backward delivery some business has been done at 21s. Here, again, the weather is an important factor, and the prevailing storms this week are telling on the market.

Freights.

The market is rather quieter than last week, and rates are slightly easier for Mediterranean. Bay very firm.

The Iron and Steel Trade.

So far there are few signs of the boom reported in other quarters. It has been stated that Germany has so much home requirements that exports have ceased. They may have lessened, but Newport received 1857 tons of steel bars from Antwerp this week. Certainly little pig has come to Wales—Swansea imported 1350 tons. From Stockton a cargo of steel rails and iron work was received by Guest and Nettlefold. Newport, in addition to many cargoes of sheet iron to Bristol, despatched nearly 1000 tons iron spikes, and 773 tons galvanised iron to Liverpool. The iron ore import business has been brisk. Cardiff imported 17,000 tons, and Newport 2700 tons, chiefly from Bilbao and Passages. Dowlais, last week, showed a falling off in steel manufacture, and the reason assigned was a lack of orders. The Goat Mill was not brisk. The Big Mill handled a fair quantity of colliery rails, angles, and fish-plates. In the Swansea Valley pig iron production was brisk, and steel smelting was quite up to the average. At Llanelly there was no falling away from the gratifying reaction of late. The principal subject of regret was that the chief works were so well off with orders that they could not take advantage of the improved prices that are now prominent. Pig iron prices are advancing. From last week there has been a distinct change. At the Metal Exchange, Swansea, this week Bessemer mixed numbers were quoted at 76s. 3d., an advance of 3s. 3d.; Middlesbrough, 62s. 6½d., instead of 60s.; Scotch, 66s. 6d., instead of 65s. Steel bars, Siemens and Bessemer, £5 17s. 6d. to £6. Cardiff quotes heavy rails £6 10s.; light, £6 17s. 6d. to £7. Iron ore at Newport is very firm. Prices:—Almeria, 21s. to 21s. 6d.; Rubio, 21s. 6d. to 22s.; Tafna, 22s. 6d. to 23s. Other quotations at Swansea this week were:—Block tin, £197; lead, £19 15s.; copper, £103 10s.; silver, 31¾d. per oz.; spelter, £28. Copper is advanced; make slightly less; home market for weldless tubes not quite so good.

Tin-plate.

One of the complaints of makers is that with block tin at £197, tin bar getting close to £6, and coal rising, the price of 15s. for ordinary plate is not remunerative. In the Swansea district the inquiry is well maintained, and it is currently suggested that 16s. would be only a reasonable price. Makers are well provided with orders for months ahead, and there is a prospect—how far suggested by hope I won't say—that the Russians may again figure largely. Some business is reported at Llanelly. Latest figures are given officially at the Exchange, Swansea, as follows:—I.C. 20 × 14 × 112 sheets, Bessemer, 15s.; Siemens primes, 15s. 1½d. C.A. roofing sheets, £11 10s. to £11 15s. per ton. Finished black plates, £11 5s.

Anthracite.

Swansea reports the market as steady, tonnage improved, and quotations in some cases above late figures. Latest: Best malting, 20s. to 21s. 6d.; second malting, 16s. 9d. to 17s. 9d. Big vein, 15s. 6d. to 16s. 6d. Red vein, 11s. 6d. to 12s. 6d.; cobbles, 18s. to 18s. 6d.; nuts, 22s. to 23s.; peas, 14s. to 14s. 6d.; rubbly culm, 5s. 9d. to 6s.; duff, 5s. to 5s. 3d. Steam is quoted at 15s. 6d. to 16s. 6d. No. 3 Rhondda at 15s. 6d. Patent fuel, 13s. to 13s. 6d.

The Colliers and the Powell-Duffryn.

An interesting case is on trial at the assizes—Moyle *v.* The Powell-Duffryn Steam Coal Company. Over 100 colliers claim various sums, owing, it is alleged, to insufficient work being provided for them on certain dates. The company's contention is that reasonable work was provided; and, further, that by contract, and custom, the company was under no obligation to provide work or trains when prevented by fall, accident, breakdown of machinery, or other causes incidental to the working of coal.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, November 21st.

THE sensational announcement of the discovery of a deposit of hematite iron ore of high grade, amounting to an estimated supply of 200 million tons, near Port Arthur, on Thunder Bay, on the north shore of Lake Superior, has taken the steel makers by surprise. It appears that this deposit lies about 20 miles to the eastward of Port Arthur, and is three miles wide and six miles long, and is within 1000ft. of the shore of the lake. It reaches back to the Canadian Pacific Railway, which is about three miles from the shore. Nearly one hundred test pits have been sunk over the property, which is said to cover several million acres. The stratified vein runs from 8ft. to 35ft., and in some of the deeper pits the bottom has not yet been struck. It is said to be 70 per cent. iron.

A good deal of English and Scotch iron is now being imported, and arrangements are being made to import still more largely. Consumers along the Atlantic Coast and the interior are purchasing for forward delivery with a good deal of freedom. No. 1 Scotch iron is selling in this city at 23 50 dols. to 24·50 dols. Middlesbrough iron is in very active request. There is also an urgent demand from southern furnaces, and some large contracts have been placed for delivery next summer, but at present it is understood that the railroad companies are not able to make satisfactory deliveries.

All of the larger consumers of iron, including the engineering plants and the larger foundries, have again appeared in the market, and are endeavouring to extend their engagements, some of them far into next summer. Billets have been contracted for within a week in 5000-ton lots, at 30 dols. to 31 dols. at makers' mills, to be delivered within three months. Soft steel bars have been advanced 2 dols. per ton, and bar iron will also advance about the same amount. The car builders, the shipyards, and other large consumers have succeeded this week in securing the acceptance of orders for considerable material, which will be delivered between March 1st and June 1st. There is also an urgent demand for refrigerator cars, coal cars, and freight cars for general freightage purposes. The smaller mills of the country which do business within limited areas are finding that their entire capacity is taken up in meeting what might be termed local demands or the demands of customers within an area of 20 miles. The greater steel plants have had offers submitted to them this week for large quantities of construction and building material, and it is uncertain at this time of writing whether many of these anxious buyers will be accommodated.

The sale of copper has improved since last week on European account. Both domestic and foreign buyers have shown themselves in the market, and some of the orders placed are quite large. The total copper purchased for export for the past week amounts to 4445 tons, and for the first half of November 8852 tons. The increased activity abroad has been reflected in a greater demand at home.

The United States Steel Corporation has been quietly accumulating a heavy stock of tin-plates, and is therefore cutting down its output materially for next year's delivery. The deliveries of tin into consumption this month will be smaller than for several months, probably aggregating not more than 3000 tons.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. JAMES MELLING, of Dashwood House, New Broad-street, E.C., has been appointed London representative for the firm of John Wood and Sons, Limited, Wigan.

MR. P. J. MITCHELL has opened a Glasgow office to deal with Rateau patent exhaust steam utilisation plant, and that his brother, Mr. F. L. Mitchell, is in charge. This office is at 144, St. Vincent-street, Glasgow.

THE directors of the Staveley Coal and Iron Company, Limited, have appointed Mr. Arthur Westlake, son of Mr. H. Westlake, managing director, to be assistant general manager, and he will commence his duties early in the new year. Mr. Arthur Westlake at present acts as the agent of the Staveley Company in London.

ROYAL INSTITUTION.—A general monthly meeting of the members of the Royal Institution was held on the afternoon of the 3rd instant, his Grace the Duke of Northumberland, K.G., F.R.S., president, in the chair. Mr. Cyril Davenport, Mr. G. S. Hein, Sir Henry Kimber, Bart., Major P. A. MacMahon, and Mrs. Robarts were elected members. Professor A. Righi, Professor P. Lenard, Professor W. C. Röntgen, Professor J. H. van't Hoff, Professor T. W. Richards, Professor A. von Baiyer, Professor K. J. Angstrom, and Professor H. H. Hildebrandsson, were elected honorary members of the Royal Institution. The special thanks of the members were returned to Dr. M. M. Bleekrode for his gift of a portrait of the late Dr. L. Bleekrode, Hon. Mem. R.I. The following are the lecture arrangements at the Royal Institution, before Easter:—Mr. W. Duddell, a Christmas course of six experimentally illustrated lectures on "Signalling to a Distance: From Primitive Man to Radiotelegraphy," adapted to a juvenile auditory; Professor Percy Gardner, two lectures on the "Sculpture of Aegina in relation to Recent Discovery"; Professor A. C. Seward, two lectures on "Survivals from the Past in the Plant World"; Professor W. Stirling, six lectures on the "Visual Apparatus of Man and Animals"; Dr. W. N. Shaw, two lectures on "Recent Advances in the Exploration of the Atmosphere"; Major P. A. MacMahon, two lectures on "The Standards of Weights and Measures"; Professor W. W. Watts, two lectures on (1) "The Building of Britain," (2) "Recent Light on Ancient Physiographies"; Dr. W. Martin, two lectures on "Old Dutch Painting and Painters"; Dr. C. W. Saleeby, two lectures on "Biology and Progress"; Sir Alexander Mackenzie, two lectures on "Latest Phases of Music, with Musical Illustrations"; and Professor J. J. Thomson, six lectures on "Röntgen, Cathode, and Positive Rays." The Friday evening meetings will commence on January 18th, when Sir Andrew Noble will deliver a discourse on "Fifty Years of Explosives." Succeeding discourses will probably be given by Mr. Charles Welch, Sir Almroth E. Wright, Professor I. Gollanze, Mr. J. J. Lister, Mr. Dugald Clerk, Professor D. J. Hamilton, Professor J. J. Thomson, Professor G. Lunge, and other gentlemen.

NOTES FROM GERMANY.

(From our own Correspondent.)

From Rheinland-Westphalia.

CONSUMPTION in iron and steel is as extensive as before, and the number of orders received during the week was large. Producers experience considerable difficulty in the execution of orders, for supplies in raw material are scanty, and trained workmen are scarce, and several establishments have been compelled to decline the acceptance of orders for immediate delivery. Scrap iron has been advanced in price, although dealers' stocks are heavy. The business in semi-finished steel is uncommonly active. Bars have not shown any abatement in demand, but are rather more strongly inquired for than previously, bars in basic being in specially strong request, and where these cannot be obtained iron bars are taken instead. Of the plate market very satisfactory accounts can be given, the mills being engaged to their utmost capacity, and the briskness in demand has a favourable influence on prices. Both employment and demand in the machine and boilermaking departments are satisfactory. At the locomotive and wagon shops both Government and private orders secure good employment, not merely for the present, but also for the next quarter. The purchase of 16,300 goods wagons, 800 passenger, and 315 freight cars has been decided upon by the Prussian Railway Ministry. Compared with previous years, the terms of delivery are about a month longer, in consideration of the present strong occupation of the wagon factories.

The Siegerland Iron Trade.

Regarding the different departments of the iron and steel industry, most favourable accounts can be given concerning employment and demand, and there is prospect of a brilliant trade being done all through next quarter. The number of workmen has increased at many establishments, and output is rather heavier than formerly. A very good business is done in iron ore, and the total output shows a rise over former months.

Output of Pig Iron in Silesia.

In October of present year 80,550 t. have been produced, against 76,618 t. in September, 1906, and 78,993 t. in October, 1905, and since beginning of the year 747,669 t., against 711,150 t. in the same period the year before. Concerning the different sorts of pig iron, 8842 t. were foundry pig, 1265 t. Bessemer, 24,467 t. basic, 35,493 t. steel and spiegeleisen, and 28,483 t. foundry pig. Exports were nil in October, and 2115 t. since the beginning of the year. During the past two weeks a sound and rather improving business has been transacted on the Silesian iron market.

German Production in Pig Iron.

According to official statements given by the Union of German Iron and Steel Makers, the output of pig iron in October of present year was 1,073,874 t., against 1,036,753 t. in September, and 1,006,943 t. in October, 1905; 174,216 t. were foundry pig, against 180,335 t. last year; 44,459 t. Bessemer, against 36,051 t.; 693,052 t. basic, against 654,702 t.; 82,232 t steel and spiegeleisen, against 67,122 t.; and 79,922 t. forge pig, against 68,733 t. in the same month last year.

Coal and Coke in Germany.

In all districts consumption is higher than output. Noteworthy changes have not taken place recently, and the rise in prices has not influenced demand, which is very brisk for all sorts of fuel, and will remain animated during the next quarter. Likewise coke is in brilliant request, output going into immediate consumption at remunerative prices.

The Austro-Hungarian Coal Trade.

A regular business continues to be done in all branches of the iron industry, and consumption, generally, shows an increase, especially in bars and sectional iron, which was 67 535 q. higher than in October last year. Owing to the increasing activity in the building line that was noticeable at the end of the season, girders, too, have improved in demand, deliveries being 34,467 q. higher than in the same month last year. The business in heavy plates shows a decrease of 1465 q., as compared with September, but was 3523 q. higher than in October, 1905. In rails rather a languid sort of trade was done during the past months, and a decrease is perceptible, both as compared to October last year, and to September of the present year. Sales from January to October have been: Bars and sectional iron, 2,612,362 q., or 312,768 q. more than in the same period last year; girders, 1,198,184 q., or 158,665 q. more than last year; heavy plates, 344,732 q., or 37,990 q. more than in the corresponding period the year before; rails, 497,049 q., or 149,705 q. less than in the same period of the previous year. From the Austro-Hungarian coal market the old complaints of insufficient supplies and a scarcity of wagons are coming in. Fortunately the demand for house fuel has been comparatively limited until now, and this is favourable to the iron industry.

Schneider-Creuzot in Toulon.

According to the *Eclair*, rumours are afloat in industrial circles of a branch establishment which the Schneider Company of Creuzot is going to build in Toulon, chiefly for the manufacture of torpedo-boat appurtenances. The exceptionally good business formerly noticeable still continues in the French iron industry, and occupation at the different establishments is excellent. The uncertainty with regard to the future prices for raw material cause producers to be rather reserved as regards the acceptance of forward orders. For coal an advance in quotations is generally expected as soon as the mild weather has given place to frost. Even now, when comparatively little is bought for house-fire purposes, a very strong tendency can be noticed in prices.

The Belgian Iron Market.

Though the position all round is remarkably firm, the upward movement in prices has ceased for the present, last month's quotations being stiffly maintained. Both pig iron and semi-finished steel remain scarce. The lively employment of the railway and construction shops causes an increasing demand for plates and sheets, and the following prices are being quoted:—Forge pig, 67·50f. p.t.; foundry pig, 75f. p.t.; basic, 76·50f. p.t., free at works. Inland quotations for bars No. 2 are 165f., for No. 3 167f., and for ordinary steel bars 170f. p.t. Girders realise 155f. p.t. for home deliveries. The favourable condition of the plate trade is further improved by the regular demand that comes in from the briskly engaged construction shops. Current prices are as follows:—Iron plates, No. 2, and plates in basic, export, 175f. p.t.; inland, 180f. p.t. Iron plates, No. 3, export, 177·50f. p.t.; inland, 185f. p.t. Siemens-Martin plates, export, 185f p.t.; inland, 190f. p.t. Coal and coke are in strong demand, and quotations for house fuel are specially stiff, which is due to an almost entire absence of stocks rather than to a particularly brisk inquiry. In the beginning of the year inferior qualities of house coal had been sent to Northern France as engine fuel, and so winter stocks came to be very low. Supplies in engine fuel are regular and satisfactory. The abolition of the export duty from England is of much interest and importance to Belgian consumers of coal, for during the first nine months of the present year 1,050,977 t. coal have been imported from England into Belgium, against 462,267 t. in the year before.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS**, *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

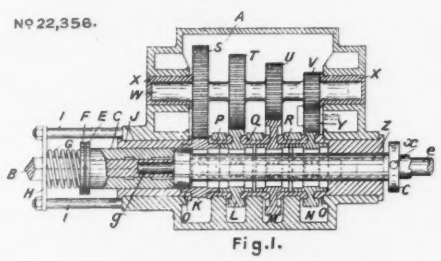
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

ROAD MOTOR VEHICLES.

22,356. November 1st, 1905.—AN IMPROVED CHANGE-SPEED DRIVING GEAR FOR MOTOR VEHICLES, Walter M. Whittington, 66, Haydons-road, Wimbledon.

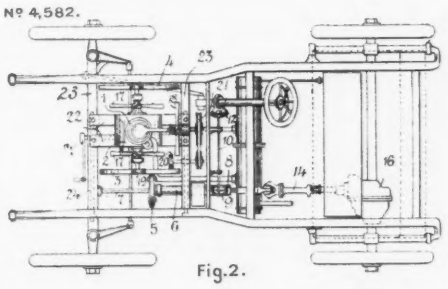
This invention relates to a change-speed driving gear for motor-driven vehicles of the type in which the gear wheels are always in mesh, the speed being changed by means of a sliding clutch which engages with clutch pieces inside the gear wheels. There are five figures. Fig. 1 is a vertical section through the gear-box. A is the gear-box. B is the engine shaft, which is made square, and fits the sliding clutch C, provided with four clutch teeth at one end and with a flange E at the other end. F is a collar also provided with a ball race. G is a spring which bears at one end against the collar F, and at the other end against the cross bar H, which is secured to the gear-box A by stud bolts I I. The sliding clutch C rotates in a bearing J. K L M N are the clutch wheels, which are spur wheels having clutch pieces on the inside of the



bosses, the wheels being provided with long bosses revolving in bearings O O P Q R. Gearing with the wheels K L M N are other spur wheels S T U V formed integral with or secured to the back shaft W, which shaft rotates in bearings X X in the gear-box A. Y is a pinion gearing with the wheels N and V to give the reverse motion. Z is a sleeve having clutch pieces *a* at one end and a ball bearing collar at the other end; *c* is a collar which is provided with lugs *x* to receive a forked lever by means of which the sleeve Z is moved longitudinally; *e* is the shaft which conveys the motion from the sleeve Z to the differential gearing or to the driving shaft. The shaft *e* is square in one part, and the sleeve Z has a square hole therein to fit the square portion of the shaft *e*, the remaining portion of the shaft and the sleeve being circular; *g* is a circular portion of the shaft *e*, which fits a circular hole in the engine shaft to form a bearing for the end of the shaft *e*.—*November 7th*, 1906.

4582. February 24th, 1906.—IMPROVEMENTS IN MOTOR ROAD VEHICLES, *Josef E. Labus*, 12, *Bujattigasse*, *Vienna*, *and Gustav J. Schreiber*, 4, *Holbgasse*, *Vienna*.

This invention relates to a motor vehicle actuated by friction gear of a known type, and consists in the construction and arrangement of the gear and of the motor, as well as in the fuel vaporiser belonging thereto. There are three figures. Fig. 2 is a plan. The motor 1 is arranged in the fore part of the vehicle with

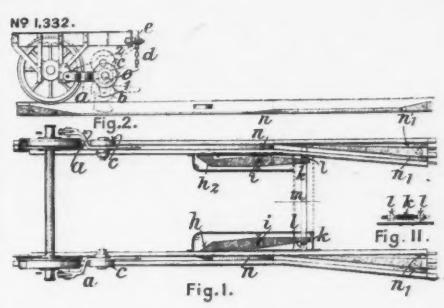


its shaft parallel to the wheel axles. The motor is furnished with two fly-wheels 3 and 4 situated outside the casing. The fly-wheel 3 is constructed as a disc, and serves for transmitting the power to the friction wheel 5, which is adjustably mounted on a square shaft 7. The friction wheel 5 is connected with a rod or sleeve 6, and rotates freely in a bearing independently of the sleeve. By the impulsion given to the friction wheel 5 from the fly-wheel 3 the shaft 7 is rotated, whilst the sleeve 6 remains at rest. In order to enable the speed to be varied as desired the sleeve 6 is moved longitudinally by means of a rack 8 formed thereon and a pinion 9. The pinion 9 is keyed on a shaft 10, and adjusted by a hand-lever on the steering-post, which is geared with the shaft 10 through a pinion and a toothed sector 12. The shaft 7 engages with the differential gear 16 seated on the back-wheel axle, through the medium of the jointed shaft 14, and thereby actuates the back wheels. The fans 17 17 are driven by friction discs 19, which rest on the rims of the fly-wheels 3 and 4. The fan 18 is actuated by a friction wheel 20 situated on the side of the fly-wheel 3 that is opposite the friction wheel 5, the shaft of the wheel 20 transmitting the motion to the fan 18 by means of belt pulleys and belts 21. The bearings of the three fans are carried on the body 2 of the casing. The arrangement of the friction wheel 20 is of importance, as the wheel acts likewise as a counter pressure wheel in relation to the friction wheel 5, whereby the bearing for the fly-wheel 3 is relieved. In order that the friction wheel 5 may always be adjusted to bear with sufficient pressure against the fly-wheel 3, the motor 1 is movable on the [-shaped bars 23 23 through its supporting members 22, which are formed with transverse incisions. Inside the [-bars screw spindles 24 are arranged which engage in suitable screw-threaded lugs in the frame members 22, whereby the motor can be adjusted in relation to the friction wheel 5.—*November 7th*, 1906.

RAILWAYS AND TRAMWAYS.

1332. January 17th, 1906.—IMPROVEMENTS RELATING TO POINT-SETTING DEVICES FOR TRAMS OR OTHER RAIL VEHICLES.—*Date under International Convention*, *21st November*, 1905.

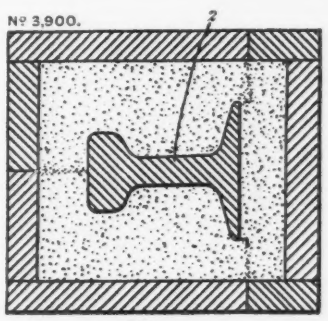
This invention has for its object improvements in devices for setting the points of tram or railways of the kind which comprise two movable shoes or ploughs which are carried by the moving vehicle, and adapted to enter the hollow formed by the rail and the check rail, either on the right or left-hand side in such a manner as to enable the driver of the vehicle running upon the track to shift the points by means of the depressed shoe, which acts upon levers arranged upon the track, and displaces the point in the desired direction without the stopping of the vehicle or the assistance of the conductor. There are twenty-four figures. Fig. 1 is a diagrammatic plan view of the device. Fig. 2 is an elevation with longitudinal section between the rail and the guard rail normal to a switch. Arms *a* are arranged beneath the driver's platform in front of the wheels. Each of these arms is provided with a shoe *b* and a roller *c*. They are connected by chains *d* to a lever *e* conveniently placed for actuation by the driver. A pawl arranged upon the handle of the lever *e* permits of locking the lever in one of the three positions 0, 1, or 2 respectively, corresponding to the ordinary running of the vehicle—the two shoes being raised above



the rails—and to switching it on to a track running to the right or towards the left hand. Two horizontal beams k_1 k_2, each rocking upon a spindle *i*, are arranged along the rail, and are provided in front with a nose presenting an oblique face engaging in a mortise formed in the web of the corresponding rail in such a manner that it is presented to the channel of this latter. These beams present at the rear a heel *k* resting upon a stop *l* of a bar *m* connecting one with the other, the two points common to a switch. In front of the tongue of each point the channel in the rail is provided with an inclined face *n*. The other inclined faces n_1 may be arranged upon either side of the switch tongue at the entrance of the two channels to which they give rise. The beams k_1 k_2 are enclosed in boxes, which protect them from operation from the exterior, and the nose of the beams k_1 k_2 traverses the guard rails at such a depth that the flange of the wheels passes over without touching it. In order to operate the switching device, the driver on approaching the points acts upon the lever *e* by displacing it at the right or left hand according to the track on to which the vehicle is to be switched. The displacement of this lever is facilitated by the fact that the arms *a a* balance each other. The shoe *b*, which has been lowered, will strike against the oblique nose of the horizontal beam k_1, and cause it to rock around its spindle *i*. This movement of the beam causes the extremity *k* to act upon the corresponding stop *l*, which by the intermediary of the connecting-rod *m*, displaces both the switch tongues towards the right hand for the purpose of switching the vehicle on to the track selected.—*November 7th*, 1906.

3900. February 16th, 1906.—IMPROVEMENT IN CAST MANGANESE STEEL RAIL, *Walter Brinton*, *High Bridge*, *Hunterdon*, *New Jersey*, *U.S.A.*

This improvement relates to railroad or street car rails, the object of the invention being to produce a cast manganese steel rail adapted for railroad or street car use, of superior quality and greater longevity than ordinary steel rails, it being particularly well adapted for use at those points in the railroad or street car system where there is greater attrition or wear, as, for instance, at curves, than at other points in the system. There are two figures. Fig. 2 illustrates a method of casting the rail. Steel rails, as ordinarily made, especially when placed at curves, quickly become worn out, so that the life of the rail is comparatively very short. It has, however, been found by practical test that rails produced from manganese steel, *i.e.*, steel composed of iron and a certain percentage of manganese, when properly made, have much longer life than ordinary steel rails. The rail 2 is cast into



the form in which it is to be used. The present practice of making steel rails is, after the billet or ingot has been cast, to subject it to a rolling process for the purpose of shaping it into the form in which it is to be used. After the rail is cast in the form in which it is to be used, and in which form it would be extremely brittle unless toughened, it is subjected to heat treatment for the purpose of toughening the rail. For this purpose it is found desirable, in order to prevent the setting up of dangerous internal and contracting strains, which cause cracks in the casting, and when the rail after it has been cast has solidified to that extent which will permit the same to be properly handled; or, in other words, when it has reached that point where its strength is sufficient to retain its own weight without warping, and it is freed from any parts of the mould which would have a tendency to retard the contraction or shrinkage which commences very soon after casting, to subject it to treatment to prevent too rapid cooling, and consequently a too rapid shrinkage or contraction, and to maintain therein a portion of its original heat determined by the size and character of the rail. This checking, or the maintaining therein of a portion of its original heat, is accomplished in one way by covering the casting with sand, or preferably placing the same in a pit prepared for that purpose, from which draughts of air are entirely excluded, so that all parts of the casting are kept

at a uniform temperature throughout, until they have cooled down to the right degree of heat for the final toughening. By means of this preparatory step, by which the rail is prevented from becoming cold or substantially so, the metal is never permitted to reach a period of rest from absence of heat, which is believed to be the cause of intense and dangerous contracting strains before final toughening, and the too rapid cooling of the rail is prevented, so that a gradual and uniform cooling down to the right degree of heat for the final toughening is maintained. The casting is then subjected to heat treatment by placing it in a furnace, it being then, preferably rapidly, heated up to a predetermined point, say, for instance, substantially of an orange heat, whereupon it is removed and cooled, usually by being immersed quickly in water, such as brine water. The tread is then smoothed or finished by grinding, which is the only practicable way of accomplishing this step, since manganese steel is difficult to cut or drill.—*November 7th*, 1906.

ELECTRICAL APPARATUS.

3127. February 8th, 1906.—Improved Apparatus for Use in connection with Electric Wave Telegraphy, Guglielmo Marconi, LL.D., D.Sc., and Marconi's Wireless Telegraph Company, Limited, both of 18, Finch-lane, E.C.

The object of this invention is to provide improved apparatus for use in connection with electric wave telegraphy, whereby a transmitter can transmit oscillations in any specific direction and a receiving station can ascertain the direction or bearing of one or more transmitting stations. A number of conductors are employed, lying in horizontal or substantially horizontal straight lines upon or at a short distance above the surface of the ground—or water—and radiating out from a centre like the spokes of a wheel. In the case of the transmitter a spark gap or oscillation producer, or in the case of the receiver any suitable receiving instrument, such as a magnetic detector, is placed where these antennæ converge, and by means of a suitable revolving switch can be connected between the end of any one of the antennæ and earth. A

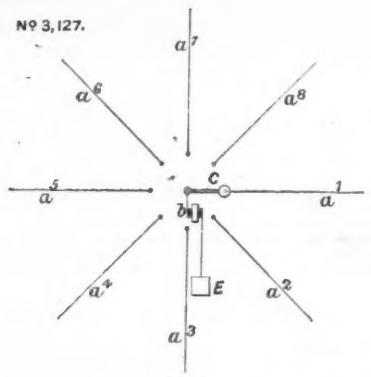


Fig. 1.

horizontal antenna placed close to the surface of the ground or water efficiently transmits or receives electric oscillations or waves in the vertical plane passing through it. If, therefore, a sending station be operating within range of the instrument and the switch be turned round and about, it will be found that the maximum signals will be received when the detector is connected to the antenna which happens to be pointing away from the sending station, or if there be not an antenna pointing exactly in this direction, then when the detector is connected to the one which points nearest to this direction. If a powerful transmitter be in operation at a short distance, it may be found that signals are obtained on all the wires, but these signals will be much stronger on the wire pointing in the already described direction. There are two figures. Fig. 1 is a plan; a^1 to a^8 are the horizontal antennæ; b is the receiving instrument connected to earth E; c is a revolving switch by which the receiving instrument or detector can be connected to any one of the antennæ.—*November 7th*, 1906.

AIR COMPRESSORS.

1843. January 24th, 1906.—Improvements in Centrifugal Air Compressors, John de Lannoy Watson, 16, White Lion-street, Pentonville, London, N.

This invention has for its object to improve centrifugal air compressors so as to produce a more silent and economically con-

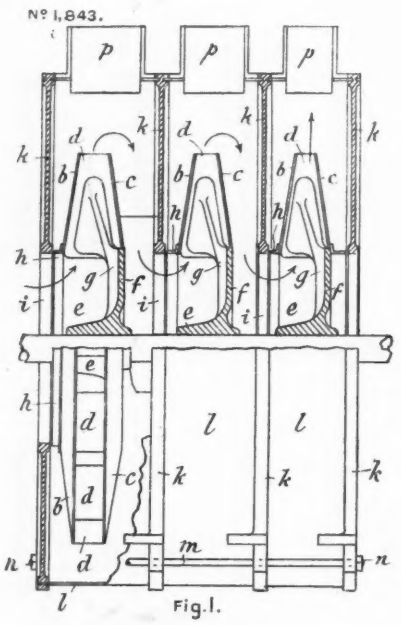


Fig. 1.

structed apparatus. There are two figures. Fig. 1 is a part sectional elevation. A number of fans of the known Sturtevant high-pressure type are composed of a pair of flat conoidal rings b c, provided with vanes d and supported by arms from a boss or hub e. The hub e is formed with a disc or flange f of a diameter sufficient to meet the ring c, and thus form the impervious side of the fan. The rings b c are supported through the vanes by means of arms g, which are integral with or attached to the disc f. The inner periphery of the ring b is provided with an annular flange or lip h, which projects towards the intake opening i in the casing, or it may project through the opening. The casing consists of a number of walls k of similar design formed with the openings i and oppositely grooved rims or peripheries, to take the edges of the sheet metal drums l, the whole being rendered air-tight and secured in position by tie-rods and nuts n. Each chamber may have an outlet p controllably communicating with a compression chamber. In the drawing only the last opening is assumed to be open.—*November 7th*, 1906.

MISCELLANEOUS.

3134. February 8th, 1906. — Improvements in Pressure-reducing Valves, *Josef Hurner and Isidore Mayer, both of XIX. /6 Muthgasse 64 (Staatbahnhof-Hetzingenstadt), Vienna, Austria.*

Pressure-reducing valves with throttling devices actuated by means of adjustably weighted or loaded diaphragms or pistons have the disadvantage that the adjusted low pressure is not maintained constant during working, as with these valves the pressure falls as the consumption of the steam increases. The cause of this deficiency is on the one hand that the load alters or slackens when the valves are opened, and on the other hand that an expansion of the diaphragm occurs, which increases with the stroke of the valve and must be overcome by the loading. This invention obviates this defect, and enables the valves in all cases, even to the largest consumption of steam, to open a passage to the inflowing pressure

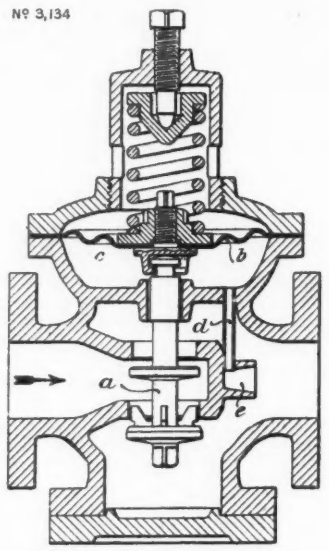


Fig. 1.

medium necessary for maintaining the adjusted low pressure. There are three figures. Fig. 1 represents a pressure-reducing valve, the throttling device of which in the form of a double-seated valve a is connected with a spring-loaded diaphragm b. The space c below the diaphragm is connected by means of a passage d with the suction nozzle e arranged in the low-pressure chamber. By the arrangement of the suction nozzle e a suctional effect is produced, which increases with increasing consumption, and is caused by the low-pressure steam flowing past. This action extends through the connection d to the space c. A reduction of pressure is produced in that space, so that the diaphragm, which is now partially relieved, can fall with the valve attached to it without hindrance and open the requisite passage.—*November 7th*, 1906.

4107. February 19th, 1906.—Improvements in the Manufacture or Treatment of Steel, Robert A. Hadfield, Parkhead House, Sheffield.

This invention has for its object improvements in the manufacture or treatment of cast steel shields, plates, and other articles of steel, whether having hard surfaces or not. A mould is prepared from a pattern of appropriate dimensions and of the proper form. The mould can be made of fire-resisting sand, dried in the usual manner. Upon one of its edges—the article to be produced being preferably cast vertically—the head or feeding portion is placed. After pouring, and preferably while the casting is hot, it is removed to a furnace where it is allowed to cool down slowly, either completely or partially, in order to prevent internal strains, after which the sand is removed and the casting carefully cleaned. For hardening the plate, after cooling down or whilst still hot, it is put into a furnace, and upon its surface charcoal is placed. The furnace is then raised to a high temperature, say between 900 deg. Cent. and 1100 deg. Cent., and the plate allowed to remain therein for several days, the actual period in a given case depending upon the extent to which the carbonising is to be carried. The plate is then allowed to gradually cool down in the furnace. The head or riser is then removed in the usual manner by being slotted off. The plate is then heated to from 700 deg. Cent. to 850 deg. Cent., and cooled down as far as desired slowly in the furnace, then reheated to between 700 deg. Cent. and 850 deg. Cent., and cooled to between 640 deg. Cent. and 690 deg. Cent., and wholly or partially, depending upon the size of the article, quenched in water, due care being taken in the latter case that it is not allowed to remain too long in the water to produce a greater degree of hardness or stiffness than required. The plate is then again heated to between 570 deg. Cent. and 640 deg. Cent., the preferable temperature depending upon the composition of the steel, and allowed to cool in the furnace. It is then reheated to between 570 deg. Cent. and 640 deg. Cent., and quenched outright, preferably in water. After this it is taper-heated; that is to say, heated so that the face assumes a temperature of from 700 deg. Cent. to 770 deg. Cent., tapering to a temperature at the back of from 400 deg. Cent. to 600 deg. Cent., whereupon the plate is dipped in, or sprayed with oil, or water, according to the hardness required, so that the face, being hotter than the back, will become hard, whilst the back remains soft and tough. In some cases, as, for example, when a very soft steel is used—that is to say, one low in carbon—a uniform instead of a "taper" heating may be adopted. —*November 7th*, 1906.

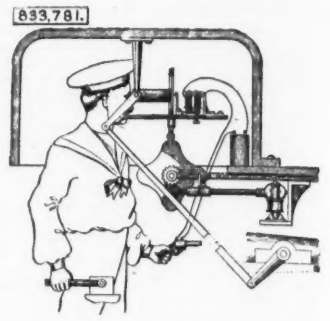
SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

833,781. Sighting Machine, *B. A. Fiske, U.S. Navy.—Filed January 2nd*, 1904.

This invention is for giving instruction in gunnery without the use of ammunition. A target picture is moved in front of the sights, and a needle is so arranged as to puncture the target the moment the gun is supposed to be discharged, due allowance being

833,781.



made, we presume, for the time of flight and the assumed range. There are five claims.

833,963. Shaft Hanger, *C. G. Harrington, Maplewood, Mo., assignor to American Car and Foundry Company, St. Louis Mo., a Corporation of New Jersey.—Filed January 8th*, 1906.

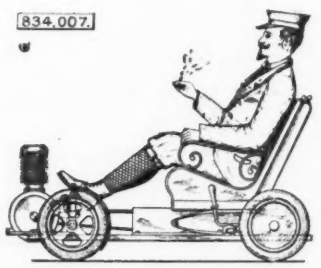
This is really a pipe hanger. The invention consists in cutt

833,963.

a hole in a plate, three sides being cut and the severed portion being driven out, as shown, forms a projection to which the pipe hanger loop is secured. There are three claims.

834,007. Motor Car, *M. Fischer, Zurich, Switzerland, assignor to the firm of M. Fischer and Co., Zurich, Switzerland.—Filed May 25th*, 1905.

834,007.

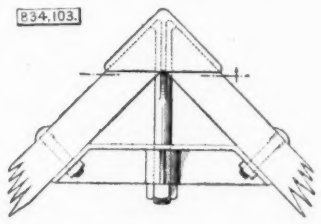


The drawing explains itself. Steering is effected by the rider's feet. There are three claims.

834,103. Corner Joint for Car Frames and the Like, *F. Bevan, Ardmore, Pa., assignor to W. E. Bevan, Ardmore, Pa. —Filed February 13th*, 1906.

There are two claims. The second adequately explains the invention. A corner joint support for car frames and the like, comprising the combination of the box entirely encasing the ad-

834,103.



jacent corner-forming ends of the car frame, the brace-piece extending between and rigidly secured to said corner-forming ends at some distance from the junction of said ends, the stem extending inwardly from said box and whose free end passes through an opening in said brace, and is screw-threaded on its said free end, and the nut on said free end, clamping said stem to said brace-piece.

Contracts.—Crompton and Co., Limited, have just received a further order from the Great Central Railway for six electric railway capstans for the docks at Grimsby.—We are informed that the machinery at the new works of the Gilbert Little Company, Limited, Bradford, has been started, beginning with contracts for coal-conveying plant for the gas producers at the new power-houses for the tramways at Winnipeg, Canada, and Bahia, South America; the Società Industriale Italiana, Rome; the Crookston Phosphate Mines, Tunis, North Africa; the Bradford Dyers' Association, Limited, for their Heckmondwike and Brownroyd Works; the Slag Reduction Company, Middlesbrough; the Manchester Book Cloth Company, Manchester; and the Cresote Works, West Hartlepool.—The Secretary of State for War has accepted the tender of Messrs. Johnson and Phillips, Limited, for supplying and erecting cables and boxes at the Royal Small Arms Factory, Enfield Lock.—The Phœnix Dynamo Manufacturing Company, Limited, has recently received orders from the Kent Electric Power Company, Chatham; the Cleckheaton Urban District Council, the Johannesburg Municipality, and from the Marylebone Borough Council Electricity Department, the orders being for motor generator and motors.

MACHINE TOOL DESIGN.

By Professor J. T. NICOLSON, D.Sc., M. Inst. C.E., and Mr. DEMPSTER SMITH.

No. XXVII *

WE now proceed to describe some examples of different types of bearings for lathe spindles, and we may begin with

BEARINGS FOR SMALL LATHES.

Figs. 98 to 104 show the types of spindle bearings most generally used in lathes up to 12in. centres. In order that the alignment may not be disturbed by wear, the journals may be made conical, as in Figs. 98 to 102. Fig. 98 shows a very early form, where the bush around the tail journal is keyed to the spindle, but can be freed to slide longitudinally upon it. In this design both journals and bearings were made of steel, hardened and

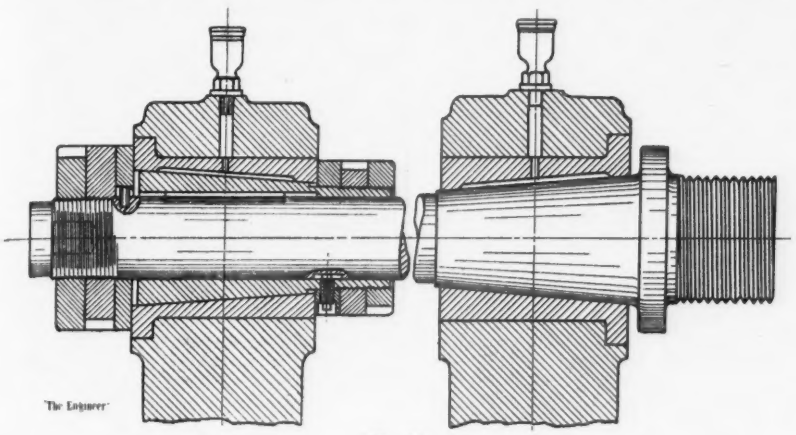


Fig. 98

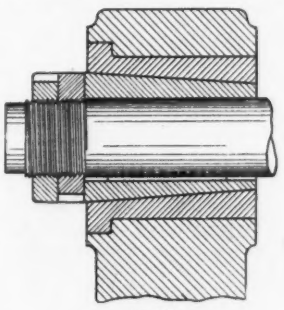


Fig. 99

ground between dead centres, then "dollied" into their places. Bearings of this class are to be seen in good condition to-day in lathes which have done hard and continuous work for twenty years. Phosphor bronze has lately taken the place of the steel for the bearings, and the spindles are made of a very hard steel containing about

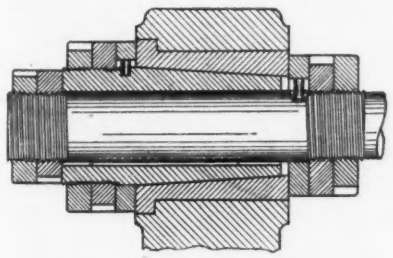


Fig. 100

$\frac{1}{2}$ of 1 per cent. of carbon, and having an ultimate tenacity of 40 tons per square inch. The front journal in Fig. 98 is tapered towards the tail of the headstock and the rear journal in the opposite direction. To allow for wear in the bearings two check nuts and a washer are fitted to the spindle beyond the tail bearing, similar provision being made on the end of the tail journal within the cheeks of the headstock. To take up the wear of the front journal the thrust bearing—not shown—is withdrawn; the screw within the washer on the tail journal is freed from the spindle, and the nuts at the tail of the headstock are tightened up until the spindle revolves in the bearing without shake. The tail bearing is then adjusted by the inner nuts on the end of the sliding bush, and the screw within the washer is locked to the spindle to prevent the bush travelling back. Finally, the thrust bearing is readjusted. The wear being more to one side of the bearing than the other, the bush is frequently turned through half a revolution in the headstock cheeks, but should be re-ground.

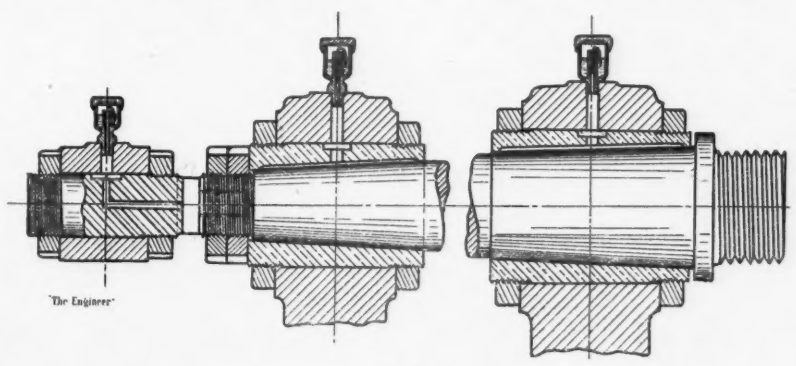


Fig. 101

* No. XXVI. appeared December 7th.

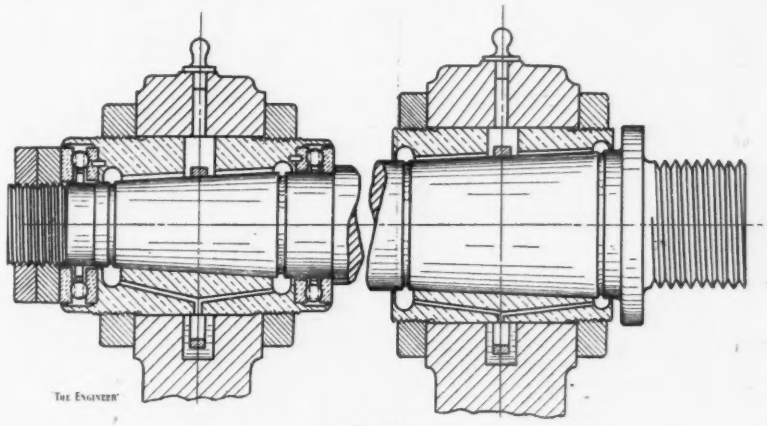


Fig. 102

Another design of tail bearing of the same class is shown on Fig. 99. Here the lock nuts and washer within the cheeks and the outer washer have been dispensed with. When the thrust bearing is withdrawn and the lock nuts on the spindle tightened up, the journals mutually adjust themselves to the bearings. When cutting towards the loose headstock, however, there is nothing to prevent the spindle travelling forward and jamming the tail bush in the bearing. To get over this difficulty and still maintain the principle of self-adjustment, lock nuts and washer should be fitted to the sliding bush, as in the tail bearing of Fig. 100. Here the spindle is adjusted in the bearings by the nuts on the tail of the spindle; the nuts on the sliding and rotating bush being slacked off whilst doing so, and tightened afterwards to take the pull on the spindle, as when cutting towards the loose headstock, whilst the thrust is taken by the washer and nuts on the spindle, and to the right of the tail cheek.

The above type of bearing has been considerably displaced by that shown in Figs. 101 and 102. In this case the cones both taper in the same direction, and independent adjustment is provided to each bearing. The bushes can slide laterally within the housings, and are locked by the nuts against the headstock cheeks. The general taper for such bearings is 1 in 6, some makers going as high as 1 in 8, whilst others, to reduce the risk of wedging, make it 1 in 5. This bearing—Figs. 102 and 103—is almost invariably made of phosphor bronze, or of cast iron lined with Babbitt metal. They are then considerably cheaper to manufacture than those previously discussed, and to this fact, no doubt, their adoption is principally if not entirely due. It is clear that unless the thrust bearing has been very accurately adjusted the spindle has a double chance of jamming in the bearings; and, in fact, the great objection to conical bearings is their tendency, by reason of the backward thrust on the spindle and improper adjustment of the thrust bearing, to produce excessive bearing pressures with metal-to-metal contact and great friction. Some writers assert that if the taper be made so steep as to prevent jamming the bearing will be too short; that, in fact, the conditions of cool running and moderate bearing pressure are mutually conflicting. This assumes that both diameters are limited. There is no reason, however, why the top diameter should not be the same as the collar beyond the bearing, against which the chuck fits. This arrangement would give a long bearing with a large taper. Another objection raised

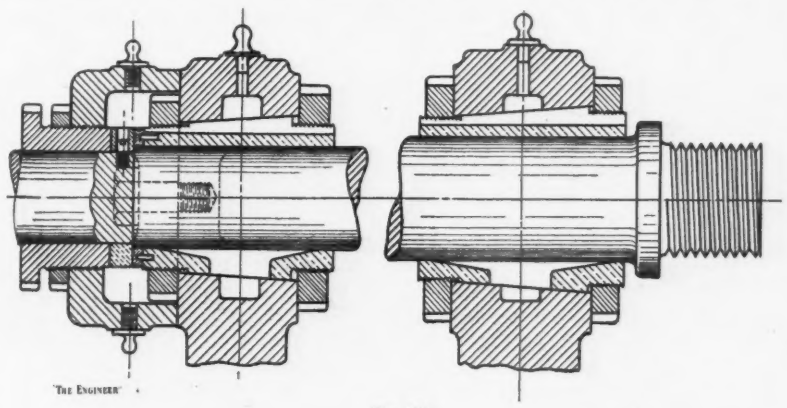


Fig. 103

is that the difference of the rubbing speeds between the top and bottom diameters of the cones produces unequal wear, and that the wear is greater at the larger diameter. This might be true if the bearing pressure decreased with the diameter, but there is no evidence that it does. Owing to deflection the pressure may be expected to be greater at the small end, and the wear might then be greater there. An examination of the bearings shows the same wear throughout their length. The above objections to conical bearings would not be heard of if their cost of manufacture could be reduced, and the necessity for careful adjustment dispensed with. The persistence of this type amongst machine tool makers of repute, after thirty years of experience with it, is strong evidence of its general correctness.

In order to obviate these supposed difficulties many makers have discarded the conical spindles altogether in favour of the designs shown in Figs. 103 and 104. Here the journals are parallel, and the bushes are coned on the outside to fit the housings or bushes in the same. The bushes are split longitudinally right across at one place, and partially at three or four other places, leaving about $\frac{1}{32}$in. of metal on the inside. Lock nuts are then fitted on each end, so that when the bush is drawn within the housing and along the cone it closes upon the journal. Each bearing has, therefore, an independent concentric adjustment by the springing of the bushes, and the spindle posi-

tion is not altered longitudinally. Although this type is now much used—more than any of the others above described—it has proved incapable of withstanding the wear, and been found almost impossible to secure a good fit without heating after at most two or three years' running. This is not surprising when it is understood

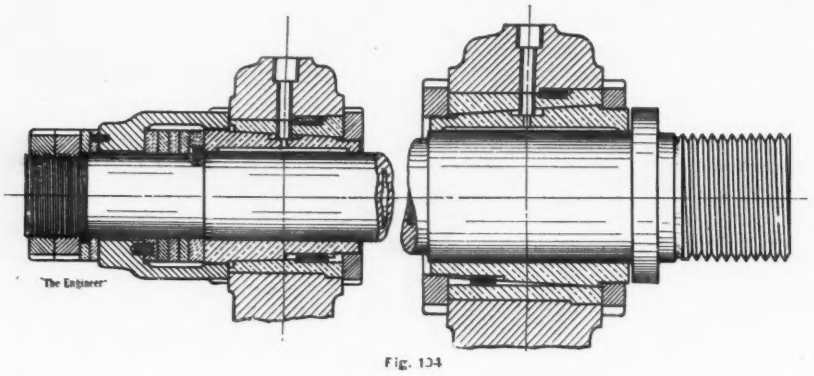


Fig. 104

that the spindle is only supported at several points round its periphery. The springy design also of the bearing makes heavy cutting impossible; in fact, there is considerable chattering when taking a comparatively small cut at a high speed. The spindle has generally been blamed for this weakness, and has been accordingly increased in

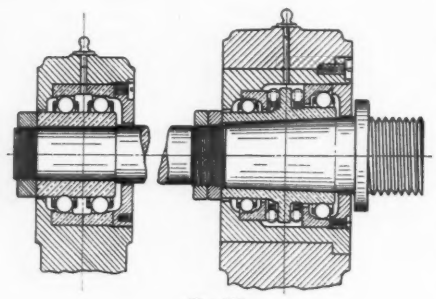


Fig. 105

diameter and fitted with new bushes. For a time it would appear that the chattering has been got rid of until the bearing becomes worn and requires to be readjusted, then the old trouble begins again, and the same process must be repeated. On the other hand, where the split bush has been replaced by a solid

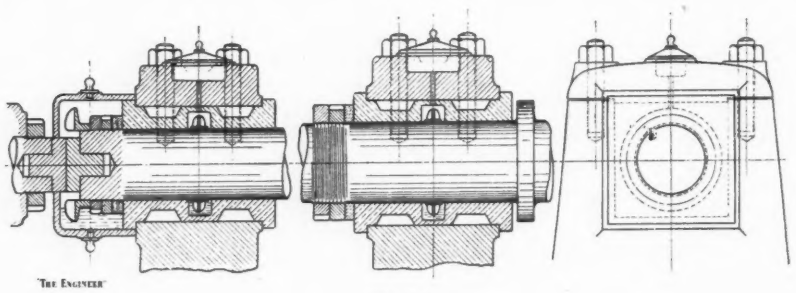


Fig. 106

one, not only has the chattering entirely disappeared, but it has been possible to take a heavier cut than before, and the wear has been vastly diminished. Now, the cost of manufacture of the design shown in Figs. 103 and 104 is considerably greater than that shown in Figs. 101 and 102—of which it is a modification—and almost as

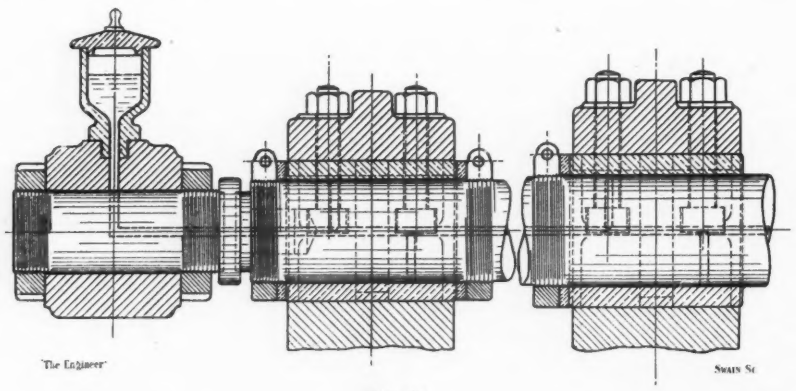


Fig. 107

great as that of the designs of Figs. 98, 99, and 100. Except the need for care in adjustment, no difficulty need be experienced with the use of the conical spindle. With an effective lubricating device it makes a first-class bearing, capable of withstanding heavy cuts at high speeds without undue wear or chatter.

Neither the ball nor the roller bearing has been used to any extent for lathe spindles, except for light lathes. The design shown in Fig. 105 is that of the Hoffmann Manufacturing Company, which has been somewhat extensively used for this purpose. The front bearing takes the form of the company's well-known double compound ball bearing. For the front journal the two outer rows of balls form the bearing proper, whilst the two rows in the centre take the thrust and pull of the spindle. The back bearing is the ordinary double-row type, although the makers have found their single-row bearing to give every satisfaction when used here. The lack of bearing surface to give rigidity, the deformation of the balls and plates under heavy loads, and their tendency to scale or crush under very moderate shocks, no doubt accounts for their application being limited to small sizes of lathes. Much the same objections may be advanced against roller bearings, which are difficult to make parallel throughout their length, and are inclined to slew and push back under the load. They are also difficult to adjust for wear.

Bearings for heavy lathes.—For the heavier types of lathes, say from 12in. centres and upwards, the parallel capped bearings shown in Figs. 106, 107, and 108, are almost universally used. The bearings are in halves, and fit metal to-metal at the centre of the journal. They are usually made of hard phosphor bronze, cast iron, or either of these lined with white or Babbitt metal. Steel is hardly ever used in this type, and the spindles are rarely, if ever, hardened. The wear is taken up by re-scraping the boxes and re-bedding the spindle, liners being fitted between the bottom half box and the headstock, to preserve the height of the spindle. The bearing is centrally placed with reference to the metal of the casting which supports it, the overhang being the same on both sides. It is held thereto by bolts and cast iron caps, which span the boxes. Fig. 106 shows the cap checked into the headstock cheek and bearing on the upper half box, but clear of the cheeks at the top to allow the cap to follow the step. To prevent any endlong movement the bearing is provided with flanges which fit on the faces of the cheeks and caps, whereas in the design shown in Figs. 107 and 108 a central bar on both sides of each half box is used for this purpose. These bars are made to fit the sides of the machined slots in the cheeks. This arrangement is an effective one, and somewhat cheaper than that just described. Messrs. Hulse cast a shelf on the front headstock cheek, on which the flange of the lower half box rests, to reduce the overhang. With the design of cap shown in Fig. 106 the transverse thrust on the spindle tends to open out the horns of the casting at the bearings.

When cutting irregular work, headstocks of this type are frequently broken diagonally across from the lower half box towards the back. Extra depth will, of course, obviate this; and some makers cast a supplementary buttress at the back. A simpler and more sensible design, however, is that shown in Fig. 108, where the cap is made to embrace both cheeks, so that when a thrust comes on the back portion it is communicated through the cap to the front. Thus the one cheek is made to assist the other.

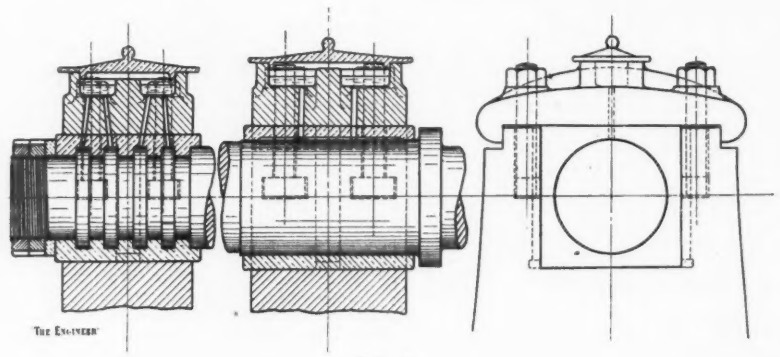


Fig 108

Although the capped parallel stepped bearings for spindles have had generally no adjustment for wear other than that already described, several American and continental makers have adopted the design shown on Fig. 109. Here a permanent tapered strip having a metal-to-metal fit its whole length, and adjusted by screws, has been made to take the place of the liners previously referred to. Amongst other styles of steps with wedge

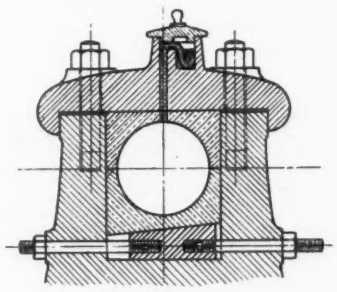


Fig. 109

adjustments which have found some favour, particularly on the Continent, are those shown at A, B, and C, in Fig. 110. The advantages obtained by making the steps adjustable by means of wedges, screws, &c., for large lathe spindles, are questionable; as there is always a tendency to chatter with so many pieces. In most lathes the spindles have to be large to withstand the torque; a wide bearing surface can be obtained by a suitable length of bearing, without lengthening the headstock, as the gears are usually carried on the side shafts, and the wear is reduced to a minimum. Thus the periodical examination of the steps and their overhaul (as with bearings in halves) may be expected to give the most satisfactory results.

Thrust bearings.—In small lathes the methods generally adopted for taking the thrust and pull of the spindle are shown in Figs. 100 and 101. In Fig. 100 the washer and check nuts on the spindle at the right-hand side of the bearing take the thrust, whilst the pull is taken by the washer and nuts on the rotating and sliding bush at the left-hand side of the bearing, any lateral movement of this bush being prevented by the check nuts on the

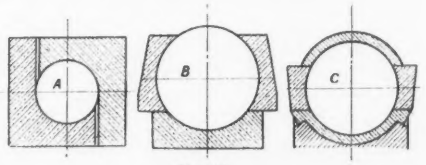


Fig. 110

end of the spindle. In Fig. 101 the thrust is taken on the pin in the thrust block at the tail end of the headstock. The block is fixed to the headstock by studs or bolts, and the thrust pin is adjusted and held in position by the nuts on each side of the block. The pull of the spindle is taken by the check nuts on the end of the spindle, which bear against the bush in the cheek. To prevent the turning of the nuts by the friction between them and the bush, a washer pinned to the spindle, so that it will rotate with it, is introduced between the nuts and the bush, as in Fig. 100. Without this there is a tendency for the nuts to turn, and lock or release the spindle, depending on the direction of rotation and hand of the thread.

For convenience in construction, and to reduce the distance between the front driving wheel on the spindle and the face plate, and the overhang of the latter, the thrust bearing is generally placed at the tail of the headstock. The pull and thrust should be taken as near to one another as possible, so that, in the event of the spindle or bearing heating and lengthening, jamming and excessive friction are reduced to a minimum. With this object in view, Messrs. Wm. Sellers and Co., Philadelphia, U.S.A., devised an arrangement similar to that shown in Fig. 103. Here the thrust and pull are taken on each side of a hardened steel collar pinned to the spindle. The thrust block takes the form of a cup, and is bolted direct to the facing on the tail cheek of the headstock. The thrust pin here takes the form of a ring of hardened steel, and through it the spindle may pass in order to receive the feed wheel or the driving wheel to the reversing gears, which may be placed outside the cheek without undue overhang. The cup is screwed to receive the thrust ring, which is provided with a locking nut, and bears against the collar on the spindle. The spindle is slightly reduced in diameter to form a shoulder against the collar, and so transmit the thrust. On the end of the bush within the cup is pinned a hardened steel washer, against which the collar on the spindle bears to take the pull.

A similar arrangement to the above is shown in Fig. 104, where multiple steel and phosphor bronze washers are used to reduce the liability to seize. In this case the cup and thrust block is combined with the nut on the end of the adjustable bush, and a hardened and ground steel washer is pinned to the inside of the cup—which it would be difficult to grind or harden—to receive the thrust of the spindle. A similar washer pinned on the outside of the cup, bearing against another on the spindle, supported by the cheek nuts, takes the pull of the spindle.

The thrust bearings shown in Figs. 106 and 107 are almost identical with that of Fig. 101, with the exception that provision is made at two places in each case to take the pull on the spindle, viz., on the left-hand side of the front and back cheeks. In Fig. 107 the nut on the right-hand side of the rear bearing is intended to assist the pin to take the thrust. A recessed phosphor bronze washer is introduced between the tail of the spindle and the thrust pin, which can be readily replaced. A split nut provided with a lock bolt takes the place of the usual pair of nuts. In large sizes the keys for these nuts are clumsy to handle, making a delicate adjustment very difficult, as both keys have to be worked together when locking. With the split nut adjustment can be more easily made, and the nut locked by an ordinary spanner. Both these methods have been largely used by several firms in heavy lathes; but in view of what has already been said about the expansion of the bearings and the spindle, the design of Fig. 107 is not good practice in this respect. Where this design has given no trouble, the rubbing speed has been low, and there has been abundance of bearing surface, and consequently little or no heating. As a general rule, however, all the nuts have to be eased off when the lathe gets cold, and they only bear when warmed up by running. The mechanic fails to take into consideration this change in the condition of the parts, and concludes that it is next to impossible to adjust such bearings. In some cases it has been only when the troublesome thrust bearing has been withdrawn that the machine has worked satisfactorily. The design is altogether unsatisfactory, and is the outcome of a desire on the part of the makers to err on the safe side by securing in a cheap way an abundance of bearing surface. If provision is made for copious lubrication all the necessary surface can be easily obtained by one surface. This is equally true both for the thrust and the pull, although the former is generally greatly in excess of the latter. Some makers prefer, for heavy lathes, the design shown in Fig. 108, which is really the marine propeller shaft thrust block. The thrust is here distributed over several collars, and the pull is taken by the washer and nuts on the tail of the spindle.

THE NEW INCANDESCENT ELECTRIC LAMPS.

No. II.*

Zirconium lamps.—The metallic carbides can be divided into two classes; those comprising the one class are decomposed by water, the others remain quite unchanged. Zirconium carbide belongs to the latter class, and has lately been used for the manufacture of incandescent filaments. According to the Sander patents—D.R.P. 133,701, 137,568, and 137,569—the technical exploitation of which in Germany after the dissolution of the Electrodon Gesellschaft was taken over by the Zirkon-Glühlampenwerk of Dr. Hollefreund and Co. in Berlin, zirconium incandescent bodies are manufactured from the hydrogen or nitrogen compounds of the rare earths, especially of zirconium by the aid of some organic binding material. In the preparation of these compounds zirconium oxide, for example, is reduced by means of metallic magnesium, according to Winkler's process, in a current of hydrogen or nitrogen. For the sake of convenience hydrogen is used in practice for this purpose. Contrary to the analytical results of Winkler and Bayle, the pure hydrogen compounds should be obtained, if, according to the assertions of the patent, an excess of metallic magnesium is used, and heat is applied externally. Hollefreund has, so we understand, declared that the analytical results certify the formula to be ZrH_4. In order to remove the magnesia and the excess of magnesium, the product of the reaction is digested with dilute hydrochloric acid; it is then dried and made into a paste by the use of an organic binding material. The filaments produced by pressure are advantageously heated in an atmosphere of hydrogen to about 300 deg. Cent., in order to prevent oxidation. These filaments possess, however, an exceedingly low conductivity, so that they must either be started with a current of high voltage or be first heated up by means of some heating medium. If the latter process be used, a current of ordinary voltage is sufficient to keep the filament in a state of incandescence. When this has been done, the filament is continuously conductive, since the formation of carbide has been brought about. Hydrogen is then conducted into the receiver, and the current is allowed to increase gradually in order to make the filament coherent. As the current gets strong the filament alters its structure, becomes hard, shows a metallic appearance, and in its electrical properties resembles a metal. The incandescent lamps manufactured by this process, according to the assertion of Wedding, required 2 watts per candle, and were adapted for currents of low voltage.

The same company also put upon the market for a short time a so-called zirconium carbon lamp, which consisted of an ordinary carbon filament, having on its exterior surface, instead of as formerly, a graphite coating, a thin layer of zirconium metal. According to patents relating to this process—D.R.P. 140,323 and 141,353—the carbon filaments are heated electrically in a receiver in an atmosphere of gaseous zirconium compounds, whereby, for instance, 25 candle-power lamps may be converted into lamps of 30 to 32 candle-power burning at 220 volts with 2·5 watts, which show, therefore, the same economy as our present high voltage incandescent carbon lamps.

The firm Hollefreund and Co. have lately put on the market an improved zirconium lamp, which is supposed to burn with 1 watt per candle. As it is called a zirconium lamp, it might be imagined to be a metal lamp, analogous to the osmium and tantalum lamps. From the recent patents, however—D.R.P. 140,378, 146,555, 147,233, and 147,316—it appears that it is a carbide lamp, in which the proportion of carbon is reduced by suitable additions and treatment. To apply carbide for incandescent electric lamps is not new, since long before the publication of the Sander patents proposals were not lacking to apply carbides of the most diverse metals, including zirconium, for such purposes. Since, however, the results produced with carbides did not correspond with the expectations, this direction was overlooked.

It was by the addition of other suitable difficultly fusible metals, such as ruthenium or tungsten, for instance, that incandescent filaments were first obtained whose melting points lay very high, and which could be put to severe tests without prejudice to their durability. According to Boje, these lamps burnt 60 hours at 0·3 watt per candle; for over 120 hours at 0·6 watt; and for over 1000 hours at 1 watt. At this rate they show in the first 500 hours almost constant illuminating power. The length of the filament amounts to about 5 mm., with 0·6 mm. thickness for one volt, so that it is necessary to have a number of filaments in series in order to produce incandescent lamps adapted to 110 to 220 volts.

Iridium lamps.—About the same time an iridium lamp made its appearance. Iridium, the application of which to electric lamps Edison had already proposed in 1878, is exceedingly hard and brittle, and cannot, therefore, be drawn into wire. But it can be rolled out into sheets about 0·8 mm. in thickness. The use of iridium for incandescent lamps is now rendered possible by the Gülcher process—German patents 145,456 and 145,457. As hitherto nothing has been published on this subject, it may be of interest to quote here the patent claims: "Process for the manufacture of thin and uniform lamp filaments from pure iridium, in which the iridium in a finely divided state is mixed with a binding material and dried in the air at a low temperature, and then strongly heated in the air, whereby the binding material is removed and the metallic iridium is left in a perfectly coherent form."

"Process for the manufacture of thin and uniform lamp filaments from pure iridium, according to patent No. 145,456, which sets out that the amorphous iridium is intimately ground with the binding material, whereby a somewhat stiff plastic mass is formed, from which the filament is produced. After drying, the filament is exposed to a current of hydrogen, whereby any oxide still remaining is converted into metallic iridium; then the filament, consisting only of metallic iridium and the binding material, is heated to a high white heat in contact with air."

The iridium lamp, like the osmium lamp, is only adapted for low voltages, and cannot by any means be considered as a real competitor of the carbon filament lamps, since the natural supply of iridium is, like that of osmium, very limited. The accumulator works of Gülcher in Berlin has probably only taken up this branch of manufacture because it has been shown that the osmium lamps are specially well adapted for low voltages and small light power. Lately they were almost exclusively used in conjunction with accumulators. Their relatively high price has in any case induced Gülcher to manufacture a similar but cheaper lamp.

Tungsten and molybdenum lamps.—To the metals which, on account of their high fusion point and non-volatile nature, are specially adapted to serve for glow lamps, belong tungsten and molybdenum. The idea of using tungsten and molybdenum for electric light purposes is by no means new, since several processes are known in which platinum or carbon filaments are coated over with a layer of these well-known metals. A process which was lately protected in the Austrian Patent-office by Dr. Alexander Just and Franz Hanaman—German patent 154,262, applied for 15th April, 1903, accepted 8th September, 1904—relates, however, to the manufacture of electric filaments from pure tungsten and molybdenum. It appears that the oxyhalogen compounds—for instance, the oxychlorides of these metals—are reduced by hydrogen at red heat with the formation of the metal, the halogen hydrogen compound, and water. An incandescent metallic or carbon filament was brought into an atmosphere of tungsten oxychloride vapour and excess of hydrogen, the reduced tungsten then deposited on the carbon or metallic filament, and so produced a body consisting of a core of carbon or metal and an envelope of tungsten. Researches have now shown that the reaction under known conditions runs in quite another manner. For instance, if a carbon filament is placed in an atmosphere of tungsten oxychloride in the presence of only a very little hydrogen, and heated to a high temperature by means of the electric current, it is thereby completely converted into a filament of pure tungsten. This process is exactly analogous to that one which has already been used for the manufacture of osmium filaments by the glowing of a carbon filament in an atmosphere of osmium tetroxide. In the case above mentioned the carbon combines with the oxygen of the oxychloride, forming carbon monoxide, the chlorine is reduced to hydrochloric acid, and the tungsten deposits in the place of the carbon according to the equation:—

$$WO_2Cl_2 + C_2 + H_2 = 2\,HCl + 2\,CO + W,$$
or, $$WOCl_4 + C + 2\,H_2 = 4\,HCl + CO + W.$$

Once the carbon is completely replaced by tungsten, the current of hydrogen is purposely increased, and the tungsten deposits still more on the filament of tungsten already formed. It is, therefore, made stronger and more uniform, according to the following equation:—

$$WO_2Cl_2 + 3\,H_2 = 2\,H_2O + 2\,HCl + W,$$
or
$$WOCl_4 + 3\,H_2 = 4\,HCl + H_2O + W.$$

The essential conditions which promote that reaction in which the carbon is replaced by tungsten are an excess of oxychloride, the presence of a very small quantity of hydrogen, and a high temperature of the filament. When there is an excess of hydrogen and a lower temperature of the filament the reaction proceeds quite differently, the oxychloride being reduced by the hydrogen alone, without the carbon entering into the reaction. In the case of molydenum the reactions proceed in an analogous manner. The patent claim states as follows:—"Process for the manufacture of incandescent filaments for electric light from tungsten or molybdenum, carried out by heating a carbon filament to a high temperature by means of an electric current in the vapour of oxyhalogen compounds of tungsten or molybdenum in the presence of a little free hydrogen, whereby the carbon is completely replaced by tungsten or molybdenum respectively."

In January, 1901, Dr. Fritz Blau and the Glühlampenfabrik Watt applied in Vienna for a patent for a process for the transformation of filaments of carbon into filaments of osmium and ruthenium. The claim runs as follows:—"Process for the transformation of light-giving bodies of wire form of carbon into such of osmium or ruthenium, so arranged that thin carbon wire—incandescent lamp carbon—is burnt in the absence of foreign reducing gases by the oxygen of the tetroxide of the platinum introduced in the form of gas, whereby the carbon wire is converted into metal wire."

Although the present manufacture of osmium lamps is not carried out in accordance with these processes, but exclusively by the paste method, nevertheless it may be of historic interest, and illustrate the connection of the Just patent with the Blau patent, if we give some account of them here.

According to a more recent patent application of Dr. Just, dated February 3rd, 1905, relating to supplementary processes to the substitution process, we find that the inventor has completely left the method set forth in his claim of April 14th, 1903, and has gone over to the so-called paste process as it was brought out by Auer von Welsbach for the osmium lamps. This particular claim runs thus:—"Process for the manufacture of lamp filaments from tungsten or molydenum, or alloys of these metals so carried out that the compounds of these metals, capable of being reduced to metal by means of hydrogen—such as oxide, sulphide, chloride, &c.—are worked up in powder form with a binding material free from carbon (such as water or any other fluid which leaves no residue on evaporatingin to) a plastic mass; the latter is then pressed into the form of the filament, and heated in an atmosphere of hydrogen until reduced, after which the product produced is either directly or after a drawing process used as a lamp filament.".

It is well known, however, that the substitution process is now being used, since according to a communication of the incandescent lamp department of the Vereinigten Elektrizitäts Aktien Gesellschaft of Ujpest, of April 29th this year, the first-named substitution process of Just and Hanaman is of especial value, since it permits of the production of exceedingly fine filaments of pure tungsten, whereby it is possible to produce lamps for 110 volts pressure, and relatively low candle-power, i.e., 32 candles. The firm lays particular emphasis upon the fact that filaments of so small a diameter cannot be produced by the paste method.

The exploitation of the tungsten lamp, after the process of Just and Hanaman, was executed by the incandescent lamp works of the Vereinigten Elektrizitäts Aktien Gesellschaft of Ujpest, which possess the monopoly rights for Austria-Hungary, Russia, Belgium, Italy, Spain, and Portugal. The German patent is the property of the Wolfram Aktien Gesellschaft of Augsburg, which has passed on the manufacturing rights

* No. I. appeared December 7th.

to the firm Georg Lüdecke and Co., of Lechhausen.

The process of Just and Hanaman is therefore connected with carbon. Since the present state of affairs never gives complete satisfaction, great efforts have been made to avoid the necessity of using carbon. Werner von Bolton has shown how to make wire from difficultly fusible metals, and lately, the chemist, H. Kuzel, of Vienna, has protected by patent a process which permits of the production of undrawn incandescent filaments from difficultly fusible metals in the form of amorphous powder without the aid of an organic binding material. As the working of the Kuzel patent for Germany has been taken over by the well-known Berlin firm Gebrüder Pintsch, and in Austria lamps are already being manufactured in accordance with the Kuzel process by the firm Kremenecky, in Vienna, an extract is given in the following lines from the only patent which has yet been granted, namely, the English one—No. 28,154, of 1904, filed December 22nd, 1904, accepted December 21st, 1905. The new process makes use of the difficultly fusible metals—chromium, manganese, molybdenum, uranium, tungsten, vanadium, tantalum, niobium, titanium, thorium, zirconium, platinum, osmium, and iridium—in their colloidal state, namely, as "hydrosols," "organosols," "gels,"* or in colloidal suspension. The metals are obtained in this form by well-known methods in a more or less fluid or gelatinous state, which depends, of course, upon the quantity of solvent. The colloidal metals can also be obtained in solid form by careful evaporation of the solvent, or also by drying such precipitated "sols," "gels," or metals in the form of colloidal suspension. In the first case, so much of the solvent of the "sol" or "gel" of one or several of the known metals, separated by evaporation, pressure, or filtration, that a paste is obtained; in the other case, to the finely divided metal is added a small quantity of water, or some fluid which can replace water, such as alcohol, glycerine, chloroform, xylol, and the like. By so impregnating, the colloidal metal the desired paste is obtained.

Such is the new discovery of Kuzel. The treatment of the pasty mass until it becomes a finished filament is carried out in the well-known method. The filament is pressed out of the paste, and dried; since in this form it does not conduct current, it is first heated, and then subjected to a high-voltage current, exactly as we have previously described for the carbide filaments. By heating to a white heat the colloidal metal changes into the crystalline form. The diameter of the filament and the specific resistance are thereby essentially altered. After heating to white heat the filaments are ready for use. The colloidal metals, which were previously only applied in isolated instances in medicine, appear, therefore, to be adapted to lead us nearer to the long-desired solution of the problem of economical electric lighting—so at least. testify the experimental results of Kremenecky and others would appear to testify.

The Auer Osmiumlicht Unternehmung have in their latest patent claims only registered for protecting such variations of their methods of manufacture as they have found advantageous in the employment of other metals than osmium. Otherwise they adhere to their tried paste process. The claim of a patent application of March 15th in the current year runs as follows:—"Process for the manufacture of filaments for electric lamps from tungsten or molybdenum, without the application of a binding medium containing carbon, brought about by rubbing the trioxide or acid hydrate of these metals with an excess of liquid ammonia to a viscous mass, and then working this up into filaments in the well-known manner."

The many years' experience in the manufacture of osmium lamps, which the Austrian and German Auer-Gesellschaft have at their disposal, stood them, of course, in good stead in connection with their new metallic filament lamps, which they are putting on the market under the designation Osmin and Osram lamps. These new Auer lamps probably contain tungsten as an essential constituent for this metal appears, up to the present, to have turned out the most suitable of all the metals tried for incandescent electric lighting. The Osmiumlicht Unternehmung, in Vienna, are introducing lamps of 110 volts, which they designate as "Wolfram" (tungsten) lamps. The name Osram lamp also consists of a combination or alloy of osmium and tungsten. Whilst it was formerly supposed that alloys were not suitable for this purpose, on account of the lowering of the melting point, it is now presumed that the new filaments owe their great efficiency not only to the height of the melting point of the metal employed, but also to the fact that alloys, or eutectic metallic compounds, possess characteristic physical properties which are essentially different from those of the component metals. This theory has been propounded by Kuzel.

Graphite filament lamps.—For the sake of completeness, something should also be said of the so-called "metallised" carbon filament lamp which has been produced by the General Electric Company by means of a special glowing process. Formerly the carbon filaments were, before their preparation†, strongly heated to incandescence in a suitable furnace. The most important and hitherto unknown changes are shown, however, if the prepared filaments are again heated to incandescence in a suitable electric resistance furnace at 3000 deg. to 3700 deg. Cent. The product of this treatment of the carbon filament, discovered by Howell, was very peculiar. The filaments appeared as if they had been fused by the temperature, and the specific resistance was much decreased. The decrease in resistance, compared with ordinary filaments, amounted at the temperature of the room, to about 80 per cent.

* Hydrosol, organosol, gel, and sol are the German terms for distinctive states of colloidal suspension. Reference to these is made later on in this series of articles.

† The preparation consists in bringing a carbonised cellulose filament to incandescence in an atmosphere of hydrocarbon vapour, such as ligroin vapour, whereby carbon is deposited on the thinner, and therefore more strongly glowing parts, and the thickness of the filament is made uniform throughout. This outer deposit is supposed to consist of graphite embedded in soot.

The declivity of the specific resistance was also changed by the temperature in a peculiar way, in that the negative temperature coefficient went over into a positive; so that, by the Howell process, filaments are obtained having metallic properties. In chemical aspect they resemble graphite, and therefore the name graphite filament lamps has been chosen for them. The economy so far obtained only amounts, however, to 2·5 watts per candle.

Incandescent electric lighting is still being developed; one discovery gives rise to others, as we have seen. The latest patent applications of Joh. Lux, in Vienna—No. 247,611, of September 8th, 1905—also relate to a process for the manufacture of fine filaments for electric lamps from difficultly fusible metals. A further specification by the same inventor was open for inspection on October 15th.

THE LONDON WATER BOARD.

The second annual Report of the Metropolitan Water Board was published on the 26th ult. It deals only with the year ending March 31st, 1905. Exactly a year ago, this Report—even then nine months late—was passed by the Board, and it has taken all this time to filter through the Local Government Board, the House of Commons, &c. We should add, that the House of Commons actually ordered the document to be printed on July 30th last. This process has taken some four months. It was, perhaps, to be expected that what is practically the first working Report of a newly-constituted body such as the Metropolitan Water Board would be somewhat late, but it is surely prolonging matters beyond the ordinary to keep a Report of such a character a whole year before issuing it to the public.

Those who will have the patience to go carefully into the Report will find much that is of interest, though it is difficult not to experience a feeling of annoyance when it is realised that all it contains is ancient history. Still, there is set out the fullest account which has yet been given to the public of the taking over by the Board of the undertakings of the eight London water companies. It would be wearying to our readers if we were even to indicate the mass of figures which is set out. However, we may, usefully perhaps, quote one or two particulars regarding the financial results of the operations of the Board from the "appointed days" to the 31st March, 1905. The "appointed days," it may be recalled, were the 24th June, 1904, for the Chelsea, East London, Grand Junction, Kent, Lambeth, Southwark and Vauxhall, and West Middlesex companies, the Staines reservoirs, Joint Committee and the Urban District Councils of Enfield and Tottenham, and the 25th July, 1904, for the New River Company.

It will be remembered that the Board decided to divide up its area into districts, and no longer to maintain as separate divisions the areas which had formerly been supplied by each of the companies respectively. Accordingly five districts were arranged. Taking these in the order mentioned in the Report, there was first of all the New River district. This included the area of the New River Company plus those of Tottenham and Enfield. Then came the eastern district, which corresponded with the area of the East London Water Company. Thirdly, there was the southern district, embracing the areas of the Southwark and Vauxhall and the Lambeth companies. Fourthly, there was the western district, comprising the areas of the Chelsea, Grand Junction, and West Middlesex companies; and finally the Kent district, covering the area which had been supplied by the Kent Company.

The object of this rearrangement was approximately to equalise the work done from each centre. The basis on which this was computed was that of house connections. As now arranged the numbers of connections vary from 204,308 in the New River district to 266,208 in the southern district, that is if the Kent district, with only 111,815 supplies, be left out of account. In the case of the latter it was probably deemed expedient to keep the well water distinct from the river water, and thus to preserve the peculiarly pure character of the former. Moreover, the area of the Kent district is larger than that of any other, and its population, though less at present, is rapidly growing, so that the number of supplies is certain to increase.

Altogether there are upwards of 964,000 supplies connected to the Board's mains, and the amount derived from rates for domestic supplies was, in the period covered by the Report, approximately £1,980,000. The cost of collecting the rates is something over £56,000, say 2·8 per cent. The revenue account from the appointed days to March 31st, 1905, shows that the sums received from all sources amounted to £2,000,685 8s. 9d. The deficiency during this period amounted to £9550 3s. 5d., that is to say, the expenses were greater than the revenue by this amount. We understand from other sources that the financial results of the next year, *i.e.*, from March 31st, 1905, to March 31st, 1906, showed a small surplus. The expenditure of the Board, we are told, ranges over a wide variety of matters, including very large constructive works, supply of material in bulk, rents, taxes, rates, commissions, interest on water and debenture stocks, wages of over 3000 workmen, salaries of a staff of over 500 persons, &c., and amounts to some £3,000,000 per annum. If, therefore, the income amounts roughly to £2,000,000, it is clear that the amount expended on what may be regarded as capital account must be about £1,000,000 per annum. We, however, look in vain amidst pages and pages of accounts for any detail showing how this expenditure has occurred.

On the other hand, there is a very explicit statement regarding the amount of money which had to be provided for the acquisition of the undertakings of the water companies. It will be impossible for us to go in detail into these, but we may state that the aggregate cost was £45,516,551 17s. 2d., excluding the stamp duty on vesting the costs of the Board in the arbitration proceedings, and the expenses of the Court of Arbitration, &c. These items amount to the by no means insignificant total of £387,232 19s. 1d., and the two sums together to £45,903,784 16s. 3d. With regard to this amount, however, the Report contains an auditors' note, which is as follows:—"Taking into account the conversion of the irredeemable debentures and the capitalised value of the annuities for which the Water Board have become liable, this total would amount to £47,859,839 13s. 4d."

The rateable value of the Board's area in 1904 was just over £52,000,000. It has doubtless increased in the meanwhile, but taking it at £52,000,000, it is obvious that to obtain £2,000,000 there must be a levy of something approaching 4 per cent. over the whole area in order to raise the necessary amount. As a matter of fact, we understand that it is now proposed to charge a level rate of 5 per cent. on the rateable value. As this would produce rather over £2,500,000, it would seem that since the total income of the Board was about £2,000,000 for the period under consideration, some portions of the area would have to pay considerably more than they are doing at present, though it may possibly be that other districts would pay less. Still, all would pay alike, which is in accordance with the spirit of the Act constituting the Board, and which specified that it should, within three years after the appointed day, introduce into Parliament a Bill providing for uniform scales of charges applicable throughout the limits of supply. With a central supplying body such as the Water Board, this would seem, on the face of it, fair enough; but, nevertheless, it will entail hardship on some of the districts, though others may benefit. The West Middlesex District has already had cause to feel the difference. Since Midsummer, 1887, the West Middlesex Company, having made a profit over and above its statutory dividend of 10 per cent., had allowed its consumers a rebate of from 5 to 10 per cent. off the maximum water rents. The Board began by demanding payment to Christmas, 1904, subject to a level rebate of 5 per cent.; but it ceased this after that date, and demanded payment in full without rebate. Numerous representations were received from local authorities and other consumers, protesting against the discontinuance of the rebate, and a conference of the Boroughs and District Councils in the West Middlesex District led to negotiations with a view to the legality of the Board's action being tested in the High Court. This culminated in the issue of a writ against the Board by the urban district of Chiswick. This writ came on for hearing on the 31st March, 1905, and on the 22nd of June of that year Mr. Justice Joyce gave his reserved judgment in favour of the Board.

The Report contains a mass of statistics relative to the sources of supply of water, the statutory amounts to be taken from each source, rainfall, works authorised, &c. &c. It is of considerable interest, taken as a whole, but loses considerably in value in that it has been published so long after the period to which it refers.

RECENT PRACTICE IN ELECTRICAL TRANSMISSION OF POWER.

By W. B Esson, M. Inst. C.E.

Recent progress in electrical transmission of power has been chiefly in the direction of raising the pressure on the overhead lines and in devising means whereby this could be successfully accomplished. Pressures of from 10,000 to 20,000 volts are now quite common, and there are some twenty undertakings in the United States in which the line pressure is in the vicinity of 50,000 volts. Several installations have been designed for 60,000 volts, and have worked successfully at their rated pressures. Though the majority of the latter undertakings are not yet sufficiently loaded to make the full-rated pressure necessary for regular working, they are gradually reaching that condition, and in several projects in hand the probability of being able to work some day at 80,000 volts is being kept in mind. In South Africa it is proposed to use transmission at 150,000 volts, between Victoria Falls and the Rand. On the European continent the Cellina-Venice and the Spezia transmission lines are working at 30,000 volts, while the Caffaro-Brescia, Brusio-Lombard district, and Gromo-Val Seriana lines are working at 40,000 volts. In this country, however, the highest overhead line pressure so far is 11,000 volts, this being employed in the hydro-electric power installation in North Wales.

The reason for raising the pressure is an economical one, and easily understood. As the amount of power transmitted is proportional to the product of the pressure and current, obviously if the former could be increased without limit, the latter, for any power, could be as small as we liked. Without going into all the technicalities of the matter, it may be said with perfect accuracy that just as a pipe can be made smaller when the amount of water flowing through it is reduced, so the size of the conductors in a transmission scheme can be diminished as the electric current is reduced. Now a diminished size of conductor means less copper in the line, with, of course, correspondingly reduced cost, so that the great importance of making the current low—*i.e.*, making the pressure high—is at once apparent. There is always a limit to the price which can be paid for power, and beyond which it will not pay to take it; and it is only by increasing the pressure that the cost of the line can be kept within limits such as will bring within the zone of commercial transmission places farther and farther distant.

A line pressure equal to 1000 volts per mile of transmission has been considered good practice; but this is subject to certain limitations. In the first place, it is not worth while ever having a less pressure than 10,000 volts, except for the smallest installations. Again, the highest pressures of which we have any experience on a commercial scale are from 50,000 to 60,000 volts, and as yet we cannot go beyond these even for distances of

200 miles or more. According to one eminent authority in the United States, a distance in miles, equal to three times the number of thousands of volts, may be covered without incurring an excessive annual charge per horse-power for copper. This would mean that 10,000 volts would serve for distances up to 30 miles, 20,000 volts for distances up to 60 miles, and 60,000 volts for distances up to 180 miles. The wisdom of applying the rule to any particular case will, of course, depend on circumstances; but that 10,000 volts has reached 28 miles; 30,000, 92 miles; and 60,000, 210 miles, is shown by the undertakings already at work.

The pressure which is permissible in the armatures of generators is limited, and when this has to be exceeded on the line, transformers must be employed to raise the pressure. These step-up transformers, besides adding to the cost of the equipment, introduce another link into the system, and while, on the one hand, there is, when the distances are not very great, a desire to keep the line pressure down to a figure such that step-up transformers are unnecessary, there is, on the other hand, a desire, under these circumstances to make the armature voltage as high as possible in order to reduce the line cost.

As to the armature pressure which is permissible, it may be mentioned that the single-phase alternators at the Deptford works of the London Electric Supply Corporation have for many years been generating current at 10,000 volts, a figure which, as regards the stress on the insulation, is equivalent to a three-phase line pressure of 17,300 volts. In these machines, however, the armatures are of a construction which is not practicable for three-phase power work, and consequently their behaviour affords little guidance as to what a different class of machine working under different circumstances would be capable of doing. But experience shows that there is no difficulty in winding armatures of three-phase machines of moderate size for line pressures of 15,000 volts. In the machines working at the Willesden station of the Metropolitan Electric Supply Company the armatures are wound two-phase for 10,000 volts, the stress on the insulation in this case corresponding to what would be present on a 17,300 volt three-phase line. In the Mechanicsville-Schenectady transmission the armatures work direct on to a 10,000 volt line, while the Chambly-Montreal generators and the Canadian Niagara Power Company's generators work on to 12,000-volt lines. At the power-houses of Vizzola and Paderno in Italy the armatures generate at the line pressures of 11,000 and 14,000 volts respectively. The alternators at the power-house of the Milano-Verese Railway generate at 13,000 volts, and at the power-house of the Valtellina Railway the pressure reaches 20,000 volts, the highest yet recorded. For the Valtellina design of generator this pressure is rather too high, and some troubles have been experienced. Since, to suit the railway motors, the frequency is fifteen cycles per second, the machines have only twelve poles, and there are but six coils per phase on the armatures. The output capacity of each machine being 2000 K.V.A., this necessarily means a large number of turns of fine wire on each coil. If the frequency were higher, that is, if the machines had more coils, or if the output were greater, so that the many turns of fine wire became a few turns of thick wire, the insulation would be much easier to effect, and, as a result, the machines would not be so likely to give trouble. Probably, though, for the particular design considered, a pressure of 20,000 volts is too high, there is no particular reason why, for generators of, say, 5000 K.V.A. working at from 40 to 50 frequency, this pressure should not be permissible.

Though many large undertakings, including those in northern Italy, are working at line pressures such as permit the armatures to be connected directly with the lines, it should be noted that, with the exception of the Valtellina Railway, 15 000 volts is nowhere exceeded. It may be stated as a general rule that this constitutes the limit of line pressure to which we should go without using step-up transformers, and it is unlikely that in Great Britain we shall ever require anything higher. This follows from the circumstance that it is not a matter with us of transmitting the power of water to the most distant point to which transmission is commercially possible, but of deciding, when easily transported coal is used at the power-house, what capacity of power-house shall be put up, and how far the power shall be transmitted before another power-house is added at a distance. These remarks do not apply, of course, to Greater Britain, in many parts of which water power is to be found in conjunction with great scarcity of fuel. In these localities, as in the Western States of America, the highest voltages permitted by the climatic conditions must be employed. Already we have in India the Cauvery River-Kolar transmission of 4000 horse-power over a distance of 92 miles, and going forward is the much larger scheme for the utilisation of the Jhelum River in Kashmir. This scheme contemplates transmission to a distance of 180 miles, and includes a power-house of 20,000 horse-power. Unfortunately, the orders for the whole of the extensive plant required for this undertaking have gone to the United States.

Experience shows that in designing transmission lines a careful study of local and climatic conditions should be made. Some lines furnished with the best insulators procurable have failed to give trustworthy service at a pressure above 30,000 volts, while others have given no trouble at 50,000 volts. Insulators which have passed a test of 120,000 volts satisfactorily in the manufactory have under working conditions failed at 40,000 volts in less than a month. With respect to line insulation, there is all the difference in the world between the pure dry air of the mountains and the salt and moisture-laden air of the coast.

The insulators have always formed the weak points in the line, and the risks incidental to very high voltages have been reduced as the weak places have been made fewer. By the adoption of steel poles for modern lines instead of wooden ones it has been possible greatly to increase the length of the spans, and, as a consequence, diminish the number of insulators. Whereas the usual spacing for wooden poles is forty to the mile, steel lattice poles may be spaced twelve to the mile, with the result that in the latter case less than one-third of the insulators are required. In steel pole construction Italy led the way. After the Paderno line, which was the first, the Cenischia line was erected with a similar design of pole, and with spans up to 260ft. Then came the Brembo line, part of which passes through a very mountainous district. The profile of this region presents the chain of peaks shown in the sketch—Fig. 1—and uniform spacing of the poles would have resulted in the line ascending and descending to follow in some measure the contour of the hills and valleys. As erected, the poles are placed only on the peaks, the line springing from point to point across the intervening hollows, as shown. Some of the spans are very long, 750ft. and even 920ft. being reached. Other lines in which steel poles are used are under erection in different parts of Italy; and note should be taken of a special pole being used for crossing flat country. Its design is due to Signor Guido Semenza, who has pointed out that as, in a straight level line with equal spans, the only stress to be borne by the line is due to wind pressure, it is unnecessary to employ poles

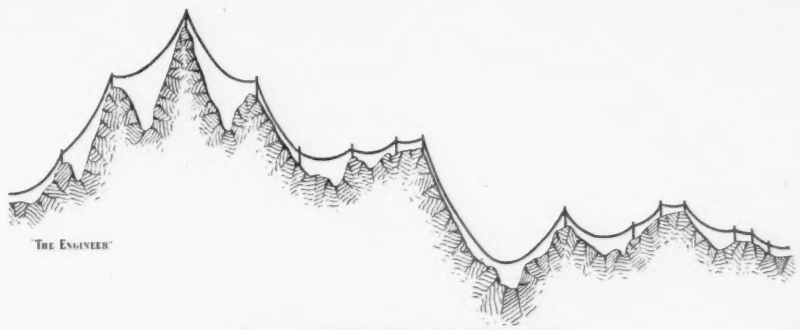


Fig. 1—BREMBO HIGH TENSION LINES

equally stiff in all directions. His pole accordingly presents great resistance in the direction of the wind, *i.e.*, at right angles to the line, but low resistance in the direction of the line. It is elastic, and can deflect over 16in. in the latter direction without exceeding the limit of elasticity, the consequence being that, in the case of a wire breaking, the poles nearest the break will bend over somewhat, thus relieving the load on the spans and preventing damage being done to the line as a whole. In Mexico there is a line designed for working at 60,000 volts, in which steel trestle poles are used spaced about 400ft. apart. Another similar line is in course of erection in the same country, and several are under consideration in the States. As the insulators are so few with steel pole construction they can be made larger, and more money can be spent on each, while their attachment to the steel poles can be made more substantial, and in better accord with engineering ideas.

The design of the insulator itself is of great importance. The subject was discussed at length in these columns last year.* The only novelty which has appeared in the interval is due to Signor Semenza, who has had large experience with the power lines in Italy. In the articles referred to it was pointed out that, in considering the arcing distance in various designs, it is to be borne in mind that in rain portions of the insulator get wet, and that the whole of the dome or outside petticoat to which the wire is attached is wet to its edge. Accordingly, for the time being the dome becomes a conductor, and may be considered as an expansion of the line wire equal to the dome's external surface. When tested for arcing distance with high pressures under rain conditions, sparks will be visible in the form of streamers all over the surface, from the binding wire to the edge of the dome, and the consequence is that in a rainstorm an insulator is only good for about two-thirds of the the pressure which it will stand dry. To improve this state of things Signor Semenza has hit upon the simple expedient of putting an umbrella over the insulator. This umbrella is illustrated in section in Fig. 3, and consists of a plate of insulating material, dished as shown, made sufficiently large to keep the dome dry and let the water run off well clear of its edge. It is claimed that the cost of insulators will be reduced 40 per cent. if this device fulfils the promise of the preliminary tests, on account of the insulators being so much smaller. Tests have shown that an insulator fitted with the umbrella will stand in a heavy downpour before arcing over 90 per cent. of what it will stand dry, or, giving the exact figures of a test, the arcing pressure in a shower was 111,000 volts against 122,000 volts dry. Insulators have to be installed large enough to meet the requirements of service in foul weather, and the ordinary type of insulator for 50,000 volts should be about 10in. in diameter. It has to be of this size because the insulation falls off so much in rainy weather; but, obviously, if means can be devised to prevent this falling off, very much smaller insulators can be used. Signor Semenza finds that a 6in. insulator, fitted with a 12in. diameter umbrella, gives as good insulation as the ordinary 10in. insulator, while the umbrella only costs a few pence. By the side of the insulator with the umbrella is an insulator of the ordinary Italian form—Fig. 2—the figures showing the relative sizes necessary for the same arcing distance. It must be admitted, of course, that this device is as yet on its probation. In localities where the cleansing effect of rain on the insulators is relied upon to keep the line in serviceable condition, the umbrella would not find a welcome. But such localities are not numerous, and power engineers will await with interest the results from the invention tested on a working line.

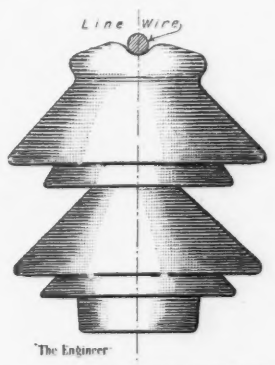


Fig. 2—ITALIAN INSULATOR

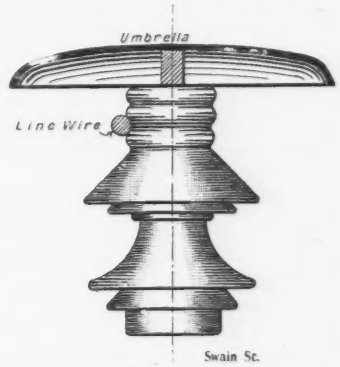


Fig. 3—SEMENZA'S INSULATOR

Lightning is still the power engineers' *bête noir*, and up to the present there is no device which can be relied upon, under all circumstances, to prevent damage from this cause. Moreover, with the high voltages now in use lightning effects are reproduced in miniature in ordinary working. A short circuit opened on a 40,000-volt 100-mile line, for example, will cause the pressure to rise from two and a-half to six times the normal voltage, as shown by the air gap jumped. As a consequence, lightning arresters, which serve fairly well for pressures up to about 20,000 volts, are unsuitable for the higher pressures. The well-known horn arrester operates well considered by itself, but inasmuch as the arc which is formed may be the means of producing surges in the circuits having just as serious results as a discharge due to lightning, this apparatus can scarcely be considered as an unqualified success. True, the California Gas and Water Company, which controls the largest transmission system in the world, has decided to pin its faith to this arrester for use on its 60,000-volt circuits, but apart from lightning not being severe in the company's area, there are many circumstances in connection with this undertaking which prohibit it from being regarded as typical of others and though the action of the apparatus is considered to have been satisfactory, it would appear as if good results were considered by the company's engineers as synonymous with an absence of results, a view which, as regards lightning arresters, is not, perhaps, without justification.

In Italy, to give the desired protection, a high resistance connection from line to ground is introduced. This is in the form of a water jet, and though on a 20,000-volt line it will act very well when dealing with minor disturbances, its capacity is insufficient to relieve the line of heavy surges. The Wurtz arrester is largely used both in Europe and America, and possibly the latest form of this apparatus with series and shunted gaps and auxiliary spark gap affords, when used in conjunction with the water jet above referred to, the best protection at present known. The problems furnished by lightning are far from solved, however, and having regard to the present state of our knowledge, it is most important that each installation be considered with special reference to the disturbances experienced in its immediate vicinity.

As regards transformers, for pressures up to 25,000

* "The Insulation of Overhead Lines," by W. B. Esson, THE ENGINEER, October 6th, October 13th, and October 27th, 1905.

volts or so, these are about equally divided between the air-insulated and oil-insulated classes. Above this pressure the oil-insulated class predominates, and above 30,000 volts oil insulation is imperative. Air-insulated transformers are cooled by forced draught, ducts being arranged so that air forced into a chamber in the transformer base is directed to cool both the coils and the iron. Up to 500 kilowatts oil-insulated transformers can be made to depend upon the oil and the containing iron case for carrying off the heat, but in larger sizes it is necessary to provide a means of getting rid of heat at a greater rate than is possible by mere radiation from the case. The method almost always used is to force cold water through a copper or brass tube coiled inside the transformer case and immersed in the oil, and this plan has given every satisfaction.

Switches for high pressure, whether operated manually or automatically, are universally of the oil break type. Simplicity is the key-note in all recent undertakings, and there is not a switch or other piece of apparatus used which can be done without. In the power-house no fuses or automatics are to be found between the generators and bus bars, it being preferable to hang on to a short rather than have the power cut off the line on account of every trifling casualty. In modern plant there are only the oil break switches between the generators and bus bars, and, as a matter of fact, the fuse as an item of power-house equipment is dead. Where step-up transformers are installed automatics are interposed between these and the high and low-pressure bus bars, but nothing else. Automatics are also used on the line.

Simplicity in the power-house can go further than this if, as has been arranged in some cases, the number of step-up transformers is made equal to the number of generators. The reason why there are step-up transformers at all is because of difficulties in generating at the line pressure, and the transformers can quite properly be regarded as an extension of the generator, in which, owing to the better insulation possible, the pressure can be raised. In accordance with this view each alternator may be combined with its own special transformer, and for the combination only high-tension switches are required to connect to the line bus bars. The consequence is that probably from 50 to 60 per cent. of all the switches in the power-house can be done away with, a result for which every engineer should be very thankful.

There is no difficulty in making a transformer of capacity sufficient to take the full output of the generator armature, if this does not exceed 2500 kilowatts, and there is no doubt that the combination of turbine, generator, and transformer, to constitute a complete unit, makes for simplicity. *Per contra*, it must not be forgotten that the transformer is the appliance that has to bear the brunt of line disturbances, and that it is for this reason the item of plant most liable to break down. Many engineers would not care to face the possibility of having transformers of equal capacity to one of their generators put out of action because of accident, and for this reason they might prefer to have twice as many smaller transformers, with the advantage of being able to connect any transformer to any generator, though with the disadvantage of all their attendant automatics. There is something to be said for both views, according to the conditions under which the plant is to work, and it is only by careful consideration of all these conditions that a wise decision can be arrived at.

As regards the general design of the power house, everything is arranged with a view to reducing labour to a minimum. This applies to both steam and water plants, though in the latter the labour is, in any case, comparatively small. In every steam power house of any size coal and ash-conveying equipment are indispensable, while to secure low capital cost, and avoid complication in the switch gear, the generating units are of such size that there are not more than eight or ten altogether when the equipment is complete. The last remark applies to water power-houses as well, though in their case the head available has considerable influence in determining the number of units. In the Sault Ste. Marie power-house in Michigan, for instance, where the fall is only 20ft., there are no less than eighty generators and turbines for an aggregate capacity of 43,000 horse-power. But this is exceptional, and it is seldom that the number of units exceed ten. As regards controlling gear, compactness in the sense of cramming everything into the smallest compass is avoided, the object being to keep everything as much as possible in full view of the operators, and to have it easily get-at-able. Accordingly the fire-trap constituted by masses of insulated wire packed away behind a switchboard is a thing of the past. We have now behind the operating panels a regular switch room with plenty of space, and a glazed floor takes the place of wood and india-rubber mats on the operators' gallery. In planning out the power-house every possible precaution is taken to prevent the spread of fire, and where step-up transformers are employed, care is taken that there are no inflammable accessories arranged so as to be easily set alight should a transformer catch fire. With regard to this point Dr. Louis Bell has truly said that waste space is sometimes the best insurance that we can have, particularly in fire risks. Finally, it may be observed that every facility is provided for the rapid replacement of, or repairs to, machinery and apparatus in case of accidental breakdown.

LITERATURE.

Monumenta Pulveris Pyrii. OSCAR GUTTMANN. Privately issued by the Author.

IT is not often that a work on a matter primarily of technical interest is issued in a form so sumptuous. Mr. Oscar Guttmann, whose status as an expert in explosives is ascertained, adds to his scientific knowledge a love for the history of his special subject, and an artistic sense not altogether usual in men of practical pursuits. He has brought together ancient pictures illustrating the history of the oldest explosive, gunpowder, and has caused them to be reproduced with the utmost care and fidelity. These he has interpreted in an account which in itself is of great interest, and as an exposition of the plates is admirable. The book being cosmopolitan, is appropriately rendered in universal languages. The pictures, as all pictures must be, are more catholic than idiograms; the text is in the three tongues, which are the modern equivalent of Hebrew and Greek, and Latin; English, French, and German versions are set forth in parallel columns, corresponding with the principal nationalities of the subscribers. The labour and love which have been expended on the book, with its paper *de luxe*, its boards—literally boards—and hand-wrought clasps, are as conspicuous in its literary part as in its magnificent presentation. While it is impracticable to reproduce the artistic beauties of the volume, it is legitimate to attempt some account of the history which they illustrate.

The author, in his preface, points out that, whilst the work, as a whole, relates to the history of gunpowder, he has thought it fitting to find a place in it for those men who have distinguished themselves in connection with modern explosives. Thus, at one end of the book, we have portraits of Roger Bacon and Berthold Schwartz, and at the other of Schönbein and Sobrero, pioneers of their respective periods. It may be recalled that, as in many other things, we in this country are so insular as to have chosen an inventor of our own; Roger Bacon is generally regarded here as the originator of gunpowder, whilst on the Continent the claims of Schwartz are preferred. It seems fairly certain that in 1242 Bacon knew of a gunpowder mixture capable of use as an explosive, but did not apply it as a propellant in a gun, whereas Schwartz was the first to use such a mixture in fire-arms. Several portraits are given of both inventors, those of Schwartz showing him with the mortar of tradition, in which his new-found mixture is prematurely exploding, and sometimes with the devil at his elbow prompting his mind to his destructive discovery. After these early portraits comes a series of pictures showing the process of manufacturing and refining saltpetre. Long before the days of nitrate from Chili, saltpetre had to be procured laboriously by collecting the efflorescence from walls or earth where nitrogenous matters had oxidised bacterially. Naturally the nitrate obtained was often the calcium salt, and with the useful empiricism of those days, refiners had found that a better product was prepared when the efflorescence was treated with potassium carbonate in the form of wood ashes. In Fig. 22 the process of maturing saltpetre beds is shown; the artist has entered into the spirit of the thing so thoroughly as to draw a sun, evidently of great power, flooding the beds with his rays. It was perfectly well known then that a good supply of heat aids nitrification, though, perhaps, the fact might not have been expressed in these terms at that date. Various pictures of the refining of saltpetre by recrystallisation are interesting as showing that they have been drawn from actual observation; the nitre is represented crystallising in its characteristic form, slightly conventionalised for ease of drawing. Testing the nitre was a simple matter in those days; if it was moist enough to roll into a ball, or if it did not taste sweet, it was condemned. Sometimes the saltpetre was fused to ensure dryness, the expert possibly not discriminating between pure potassium nitrate, which happened to be damp, and nitre containing calcium nitrate, which is deliquescent. The process recommended is quaint: "Thou shouldst cast saltpetre thus:—Put saltpetre into an earthen crucible, and add 30 parts of sulphur. Close up the crucible right well, and place it on a glowing fire, and when a blue vapour rises up, break open the crucible. Then, behold, the saltpetre will be melted, and can be cast wherein thou wish, or in whatever mould thou like." How many parts of saltpetre were to be used for the 30 parts of sulphur, and by what means reaction between the two involving the oxidation of the sulphur at the expense of the saltpetre was to be avoided, the writer of the recipe leaves unsaid.

Refining sulphur by distillation was practised much as it is at present, and the test of listening for the "crackle" of roll sulphur was early discovered, and is shown in Fig. 37. It is interesting to note that the need for charcoal of special quality was understood by the old gunpowder makers. Small twigs were used for carbonising, and lime and poplar were preferred. Attempts at improving the powder by the addition of a volatile substance were also made. For example:—"Take of camphor as much as thou wilt, and place it in a vessel and add burnt wine thereto, and lay an alambicum (still-head) upon it, and burn it out, and that which comes off the alambicum will make the powder very strong if the powder is moistened therewith. Also it may well be taken for fire-arrows and for all fire-works. Take heed to burn it very slowly with charcoal, and beware lest the vapour escape too fast, or it may be most harmful. Especially harmful is it to women."

Illustrations showing early modes of manufacturing gunpowder follow. The stamp mill is much in evidence, and it is curious to note how ancient this appliance is, and to what various uses it may be put. In this portion of the book the figures are of peculiar engineering interest. The artists of the period were original in their rendering of mechanical drawings; their notions of perspective were more than Oriental; probably the more expert were engaged in painting frescoes, or illuminating sacred pictures, the ruck being free for the service of base mechanical contrivances. Some of the figures illustrate the old belief, not yet entirely extinct, that, provided a sufficiency of wheels and gearing is employed, power can be multiplied. There is a fine picture—Fig. 55—showing a set of stamps and a corning apparatus. The description is too good to be omitted:—"This is a pouder mill, the mouement whereof is of such facilitie that after it bee once in his mocion, the workman which turneth the said mill may intend any other business y^{e} $\frac{1}{4}$ of an hower or more, and yet the mill shall not cease his motion, but both beat the pouder, and corne it all at one instant." This desirable result was to be effected by a collection of gear wheels, "lanternes"—using that word in the watchmaker's sense—and a sort of horizontal rimless fly-wheel, all of a ponderous and wooden construction calculated to absorb all the power which the most energetic workman might exert. Then follow various quaint recipes for making fancy powders—very doubtful improvements on the plain saltpetre-sulphur-charcoal mixture.

The oldest guns are described in another section of the book. The earliest gun seems to have been an iron pot from which an arrow was discharged, passing by an easy transition to a tube projecting some hard globular object—*e.g.*, a stone—and from that to artillery of a quite modern aspect. The master gunners who maintained and advanced the craft of destruction by projectiles are commemorated by a series of portraits. Perhaps the most striking head is that of Nathaniel Nye, of Worcester, taken in 1644, when a youth of twenty, wearing an air of sagacity and determination beyond his years. The book most appropriately closes with a series of admirable portraits of great chemists and inventors, such as Berthollet, Sprengel and Nobel, who have led the way from the era of gunpowder to that of explosives of the various types now in use.

Enough has been said to give some idea of the contents of this magnificent book. It was a happy conception to bring together and produce in so dignified a manner those ancient records, pictorial and written, which preserve and explain the history and growth of a material which has had an influence on the progress of mankind hardly exceeded by that of any other single substance. To the author, whose learning and discriminating enthusiasm have constructed this monument, we offer our congratulations and thanks.

SHORT NOTICES.

The Making of a Motor Car. By Douglas Leechman. London: The "Car" Illustrated, Limited. Price 1s.—Nearly the whole of the contents of this little work have previously appeared in the form of articles in the *Car*, the chief exception being the chapter on tire manufacture. The author has handled his subject in a manner which will appeal to the uninitiated perhaps more forcibly than to the engineer, who is more or less familiar with mechanical processes and workshop practice. The author commences with the offices, and then takes his readers with him through the works, describing their general arrangement before describing the many processes in detail. He explains the foundry operations, the handling and tooling of the engines, the construction of various types of frames, the cutting of the gears, the construction of chains, body building, wheel building, and the manufacture of tires. Finally, he gives the reader a good idea of the testing and "tuning up" of a motor car.

Fowler's Electrical Engineer's Handbook and Directory of Light, Power, and Traction Stations. Manchester: Scientific Publishing Company. Price 2s. 6d. net.—Several alterations appear to have been embodied in this edition of Fowler's "Electrical Engineer's Handbook." Another hundred pages of matter have been added, and the arrangement of the book has been slightly altered. The sections which have been enlarged are those relating to meters, long flame arc lamps, cable and fault testing, resistance wires, measurement of illumination, testing of alternators and transformers, the design of dynamos and motors, and special types of electric lamps. Owing to the large dimensions which the book has now assumed, it has been found imperative slightly to raise its price.

The "Indian and Eastern Engineer" Year-book for 1907. London: *The Indian and Eastern Engineer*, 50, Fenchurch-street, E.C. Price 20s. per annum.—The fifteenth issue of this excellent reference book and diary has been forwarded to us. The amount of information it contains is very large, and it is of particular value to engineers having work in or connected with India. Following the suggestion made by numerous readers, the editors have this year incorporated the electrical installation rules for work carried out in India. The rules have been compiled for them by a well-known electrical engineer in Calcutta from the regulations issued by the Government of Bengal, the Calcutta Electric Supply Corporation, and the Bombay Fire Assurance Association. There is included a three day to the page diary interleaved with blotting paper, and the whole forms a useful addition to the engineer's office table.

The Engineering and Electric Traction Pocket-book, 1906. By Philip Dawson, M.I.E.E. London: Offices of *Engineering*, 35 and 36, Bedford-street, Strand, W.C. Price 20s.—The fourth edition of the "Engineering and Electric Traction Pocket-book" has just reached us. This useful work of reference has been further improved by the addition of an up-to-date section on steam turbines. The subject of storage batteries has been more fully dealt with in this edition. Another noticeable improvement has been made in the switchboard section, which is now concise, yet quite complete. All the matter is nicely arranged, and a complete index enables any particular subject to be found with a minimum amount of trouble.

C. H. Bailey's Tables of Distances from Port to Port. Can be obtained from Mr. C. H. Bailey, Tyne Engine Works, Newport and Barry. Price 10s. 6d.—In this pocket-book the author gives tables of distances from port to port. More than 10,000 distances have been added in the present volume, bringing the total number to upwards of 40,000. It is intended as a guide to engineers and others who may require an approximate distance to compute for bunker coal, or to enable them approximately to estimate the time that a cargo steamer is likely to take for any particular voyage, weather and speed considered together. At the end of the book a few other useful tables have been given.

The British Trade Year-book, 1906. By John Holt Schooling. London: John Murray. Price 10s. 6d. net.—The "British Trade Year-Book" contains the results of a wide survey of international commerce in many directions. It contains 221 tables, which relate to nearly 700 different parts of trade. The records used are those kept by the United Kingdom, by British Colonies, and by foreign countries. The data cover the years 1880-1905, and the course of trade during that time is shown.

THE GREAT NORTHERN, PICCADILLY, AND BROMPTON RAILWAY

(For description see page 598)

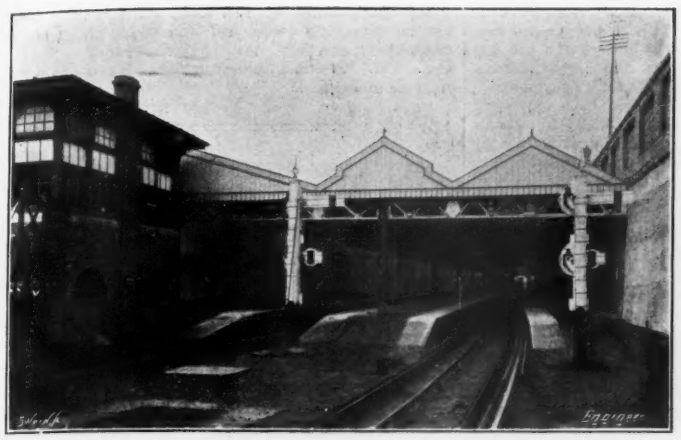


Fig. 1—HAMMERSMITH STATION

Fig. 2—HOLBORN SIGNAL CABIN—STRAND EXTENSION

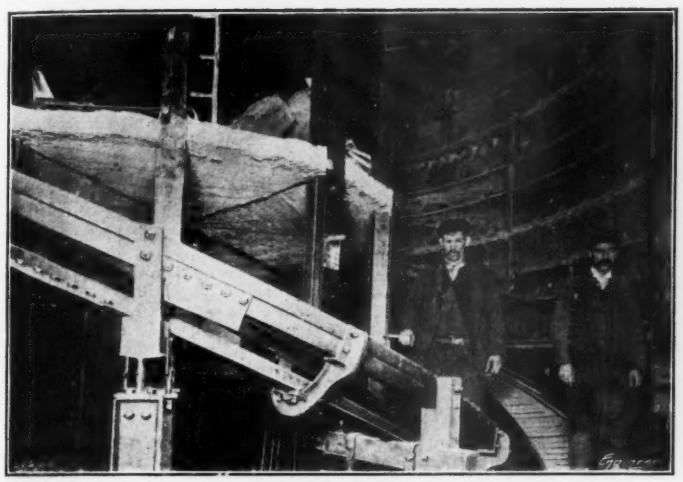


Fig. 3—HOLLOWAY REVOLVING PASSENGER CONVEYOR

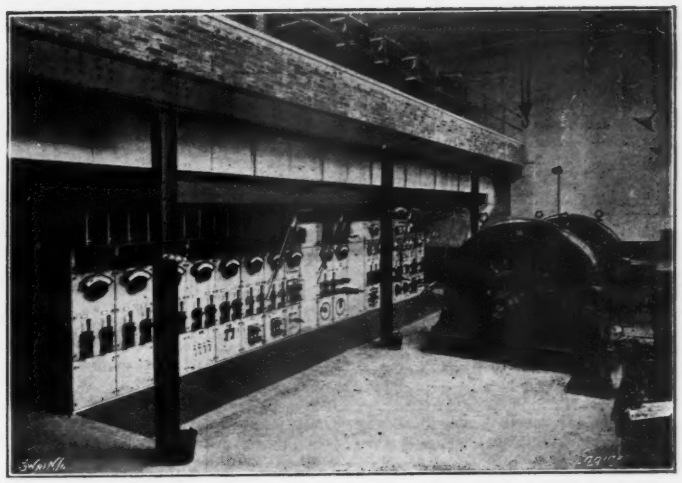


Fig. 4—RUSSELL SQUARE SUB-STATION

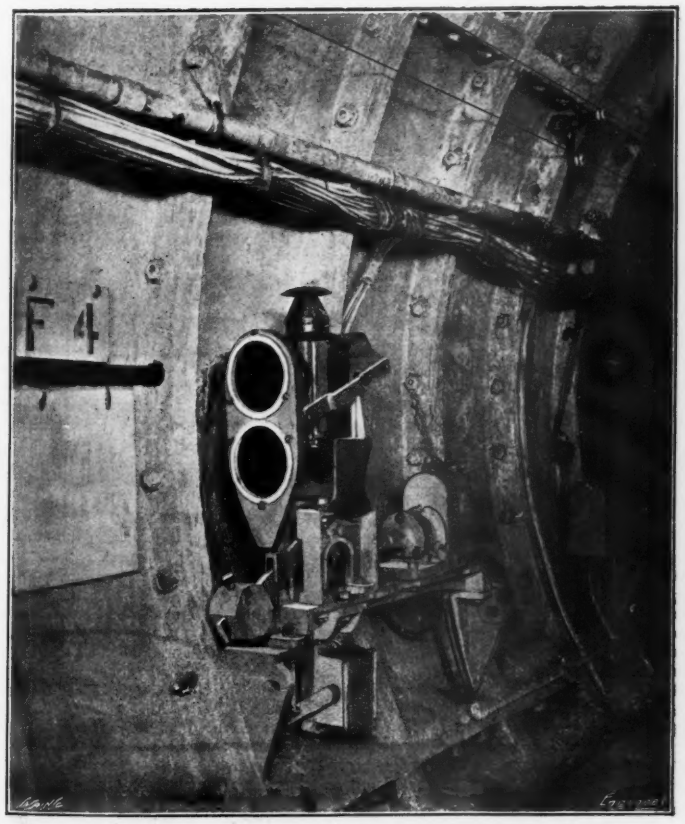


Fig. 5—FINSBURY PARK SIGNAL

Fig. 6—AUTOMATIC FOG SIGNAL

GREAT NORTHERN, PICCADILLY, AND BROMPTON RAILWAY.

TO-MORROW (Saturday) will witness the opening of another tube railway in London which will form a further link in the chain of subterranean lines projected by the Underground Electric Railways Company. The Great Northern, Piccadilly, and Brompton line will serve to connect Hammersmith on the west with Finsbury Park on the north side of London, and is 9¾ miles long, being the most extensive of the metropolitan tubular lines. Starting from Finsbury Park, the following is the order of the stations:—Finsbury Park, Gillespie-road, Holloway-road, Caledonian-road, York-road, King's Cross —Fig. 7—Russell-square, Holborn, Strand (branch), Covent Garden, Leicester-square, Piccadilly-circus, Dover-street, Down-street, Hyde Park-corner, Knightsbridge, Brompton-road, South Kensington, Gloucester-road, Earl's Court, Baron's Court, Hammersmith—Fig. 1.

At Finsbury Park and King's Cross the railway is in touch with the whole Great Northern Railway system. The St. Pancras terminus of the Midland Railway also adjoins the King's Cross Station of the tube line, and so does the station of the Metropolitan Railway. A subway is being constructed for passengers communicating with the King's Cross Station on the Euston extension of the City and South London Railway, which is now near completion. The Great Northern, Piccadilly and Brompton Railway is also at several of its northern stations close to the North Metropolitan tramway system, now being electrified. At Holborn passengers can change to or from the Central London Railway, or the Strand branch, which at the Surrey-street terminus is within about 200 yards of the Temple Station on the Metropolitan District Railway. At Leicester-square Station there is an interchange by subways with the station of the Charing Cross, Euston and Hampstead Railway, now under construction. At Piccadilly-circus there is a similar joint station with subways with the Baker-street and Waterloo Railway. At Earl's Court the Wimbledon branch of the District Railway is also available. At Hammersmith the terminus is in touch with the extensive system of the London United Tramways.

The company's system of underground railways construction has been standardised, and this line resembles very closely its sister railway, the Baker-street and Waterloo, which has already been described in THE ENGINEER. There are two circular tunnels, one for each track, and each tunnel is 11ft. 8in. diameter on the straight, 12ft. on curves of not less than 10 chains radius, and 12ft. 6in. on sharper curves. The diameter of each station tunnel is 21ft. 2½in. The tunnels are driven through the London clay, and they are lined throughout with cast iron segments in the usual way. The depth from the street level varies between 123ft. and 29ft., but the gradients are not severe. There are retarding gradients of 1 in 66 for approaching stations, and accelerating gradients of 1 in 33 for trains leaving stations. On the tunnel portion of the railway there are three single cross-overs—viz., one at Hyde Park-corner—Fig. 10—one at Covent Garden, and one at York-road, where enlarged tunnels had to be provided. There is also a double cross-over at Finsbury Park—Fig. 8—and a turn-out for the Holborn to Strand branch. On the open portion of the line there is a single cross-over at Baron's Court and a double cross-over at Hammersmith. Several sidings are also provided for leading to the car sheds at Lillie Bridge. The usual radius of the curves on the railway is 1320ft.

The track construction consists of a concrete foundation narrower than the length of the sleepers, allowing the ends of the latter, which carry the rails, to overhang, and so give a certain amount of elasticity. The sleepers are of non-inflammable Karri wood, and are spaced 3ft. 4in. apart, except at joints, where the space is 1ft. 8in. The rails are of Bessemer steel, weighing 90 lb. to the yard, and were supplied by Bolckow, Vaughan and Co. The chairs weigh 30 lb. each, and are secured to the sleepers by lag screws—a layer of pressed wood felt being interposed. The fish-plates are of rolled steel 1ft. 6½in. long for the outside, 1ft. 4½in. long for the inside, and weigh 28 lb. per pair. They are secured by Ibbotson's $\frac{15}{16}$in. bolts. The conductor rails weigh 85 lb. per yard, and have an electrical resistance 6·4 times that of copper. The positive conductor rail is close to the tunnel wall, and the negative is midway between the track rails. The ballast is composed of granite cubes. Unlike the Baker-street and Waterloo Railway, the iron segments of the tunnel are lined with concrete to a height of 2ft. above the ballast. The concrete fills the spaces and covers the flanges. This lining has been provided to prevent accidental contact being made between the conductor rail and the flanges of the lining.

The current for the operation of the railway is obtained from the Lots-road power station at Chelsea. This station is equipped with Westinghouse turbo-generators of 5500 kilowatts each, producing three-phase alternating-current at a pressure of 11,000 volts, and with a periodicity of 33⅓ cycles per second. Three-core insulated lead-covered cables, supplied by the British Insulated and Helsby Cables, Limited, are led underground from the power station to Earl's Court. Here the cables for the District, Baker-street and Waterloo, and Charing Cross, Euston, and Hampstead Railways are carried alongside the District Railway, while those for the Great Northern, Piccadilly, and Brompton line are taken down a shaft to the tunnels. These cables, six in number, are 37/13 and 37/15 in gauge, are in duplicate. They supply energy to sub-stations at Hyde Park-corner, Russell-square—Fig. 4 —and Holloway.

The electrical equipment of the sub-stations has been carried out by the British Westinghouse Company, and consists of rotary converters, static transformers, high and low-tension switchboards, &c. At Hyde Park-corner there are three rotary converters of 800 kilowatts each, at Russell-square two of 1200 kilowatts each, and at Holloway there are two of 1200 kilowatts each, and the current is transformed to 550 volts direct.

With regard to the passenger lifts, these are chiefly electrically operated, and were made by the Otis Elevator Company, but at Finsbury Park Station hydraulic lifts by Messrs. C. and A. Musker, of Liverpool, have been provided. At Holloway Station, besides the lifts, there is a passenger conveyor—Fig. 3. This apparatus has been installed experimentally by the Reno Electric Stairways and Conveyors, Limited, London. It consists of a double-spiral continuously-moving track occupying one of the lift shafts, and passengers can travel in both directions simultaneously. At the top and at the bottom the moving gangway passes for a short distance under the flooring. The speed is 100ft. per minute. The moving surface consists of wrought steel chains bridged with teak slats, and it is guided in a spiral up and down the shaft by wheels running on a spiral track. A flexible handrail moving at the same speed as the conveyor is provided, and both are driven by sprocket wheels meshing into the links of the chains.

The ventilation of the tunnel is thoroughly effected by nineteen fans distributed among the underground stations. These fans, which were supplied by Messrs. Heenan and Froude, are each 5ft. 6in. in diameter, and each draws 18,500 cubic feet of air per minute out of the tunnels. They are driven by 10 horse-power motors at 250 revolutions per minute. The fans are placed in the surface buildings, and the intakes are connected by closed air ducts, 16 square feet in cross section area, to the points of suction in the tunnels. The exhaust of the fan is through the roof of the building; 21,000,000 cubic feet of air per hour is exhausted from the tunnels.

The signalling installation is very similar to that adopted on the District and Baker-street and Waterloo lines. In addition to the signal-boxes at Hammersmith and Baron's Court, which already control the District lines, there are only boxes at Holborn and Finsbury Park. There are small boxes at Hyde Park, Covent Garden, and York-road, but these will only be opened when trains have to be worked through the crossover roads provided there. The movements of trains will be controlled by automatic signals similar to that seen in Fig. 5. The Westinghouse electro-pneumatic system is employed, and an air main passes through the tunnels and supplies air at a pressure of from 60 lb. to 70 lb. per square inch, which is admitted to the cylinder of the signal by means of valves operated by relays in connection with the track circuit. When air is admitted to the cylinder the piston is moved from right to left, and the rod, coupled to the piston, raises the weighted balance lever of the signal, so that the signal spectacle is raised. This spectacle carries a red and a green light, the red being the upper and in front of the lens of the signal lamp. When the signal has to be restored to danger the air is exhausted and the weight on the balance lever brings the spectacle down, the exhausting air acting as a cushion. The track circuits are protected from extraneous currents, and all signals, whether worked from signal-boxes or not, are automatic, inasmuch as they cannot be lowered unless released by the track circuit, and they are restored to danger independently of the signalmen. Such signals are known as semi-automatic. Generally there are no distant signals, but where the motorman's view of a stop signal is indifferent, a "repeater" signal is provided. These may be passed when in the "on" position, which is indicated by a yellow—not red—light. The "off" position is indicated by a green light.

On the Brompton and Piccadilly line there are eighty-four automatic stop signals, seventy-two semi-automatic and thirty-seven repeater signals. The length of the sections has been arranged to provide for 1½ minute headway. All the signals have been provided with Adlake long-burning oil lamps, which burn for a week without requiring any attention. The stop signals are equipped with an automatic stop. This consists of a trip by the side of the right running rail, which is connected by a rod to a small motor in series with the stop signal. When the signal is at danger the trip is up, and comes in contact with a lever on the motor car, so that the brake is applied and the train antomatically pulled up. When the signal is cleared the trip is lowered clear of the lever on the car. In Fig. 9 is a view of the stop signals at a junction. That on the left is for passing a train through the junction in the direction to the left, and the right signal is for going to the right. In Fig. 2 is seen the electro-pneumatic locking frame in the Holborn box for actuating the points and signals worked therefrom. Above the frame will be noticed the illuminated diagram. Each line controlled from the box is marked on the diagram, and the lines are divided in lengths corresponding to the track circuits. For each length there are three incandescent electric bulbs, which are switched out when the track circuit is occupied, and thereby warn the signalman of the presence of a train. As the lines on each side of the box are included in the diagram, it also shows the approach of trains.

One entirely novel feature introduced on this line is a fog-signalling machine—seen in Fig. 6—which automatically places detonators on, and withdraws them from, the rail. These are connected to the west-bound home signals at Baron's Court and Hammersmith, and the east-bound advance at Hammersmith. They are operated by a small motor similarly to the automatic stop. The machines are fixed sufficiently far in the rear of the signals to enable a driver, running with caution in a fog, to pull up his train before reaching the signal and automatic stop. An arrangement has been designed which can readily be coupled to the machines, whereby a whistle will be blown when the supply of detonators is low, and if it is exhausted and no detonator is on the rail, the whistle will sound as a warning to motormen. The detonators to the number of 50 are contained in a magazine.

The cars resemble very closely those in use on the Baker-street line, and number 216, of which 72 are motor cars and 144 are trailers. They are not of British construction. The original engineers for the railway were Sir J. Wolfe Barry and Partners, Mr. A. Ross, Sir James W. Szlumper, Mr. W. W. Szlumper, and Mr. C. A. Brereton. The Underground Electric Railways Company carried out the construction, with Mr. J. R. Chapman as engineer-in-charge. The fares for passengers will vary between 4d. and 1d., and through bookings have been arranged with most of the railways which lie adjacent to the line, as well as with the London United Tramways. The time taken by the whole journey of 9¾ miles is to be 37 minutes.

The illustrations referred to in the foregoing article will be found on pages 597 and 604. They are self-explanatory, and will not require any further explanation. They give an excellent general idea of the various portions of the line.

THE SMITHFIELD SHOW.

IT is pleasing to be able to report that the implement section of the Smithfield Club's annual show, held this week at the Agricultural Hall, Islington, exhibits no signs of loss of vitality. As a rendezvous for farmers and agriculturists the Smithfield Show continues to maintain its popularity in spite, or, perhaps, in consequence of the conservatism of its promoters. The leading makers of agricultural implements are represented year by year, and there is a remarkable similarity in their exhibits. At the present show the most prominent feature is the large number of steam tractors designed to work under the five-ton tare limit imposed by the Motor Car Act. Before the increase in this limit, from three to five tons, very few makers of road engines attempted to produce tractors, it being generally considered impossible to produce anything capable of doing itself justice under the latter figure. Now, however, the makers of five-ton engines are numerous. At Islington they include Aveling and Porter, Limited; Brown and May, Limited; Chas. Burrell and Sons, Limited; Clayton and Shuttleworth, Limited; Richard Garrett and Sons, Limited; Robey and Co.; Ruston, Proctor and Co., Limited; Savage Brothers, Limited; Wallis and Steevens, Limited; and John Fowler and Co., Limited. Many of the engines shown by these firms have already been described in the pages of THE ENGINEER. Opinion appears to be divided regarding the desirability of compounding for such comparatively small units. On the point of economy the gain by compounding is probably small, too small some makers aver, for the extra expense involved. On the other hand, the compound engine is less noisy to operate, and having two cranks, is easier to start.

John Fowler and Co. (Leeds), Limited, show a three-cylinder compound tractor which is a distinct departure from current practice. It is built on the lines of heavier engines which this firm has supplied to the War-office. The driving wheels are 5ft. diameter by 8in. wide; front wheels, 3ft. 7in. diameter by 5in. wide; the tank capacity is 100 gallons; and the working pressure of boiler 200 lb. per square inch. The three-cylinder arrangement consists of one high-pressure and two low-pressures. The high-pressure cylinder and the large low-pressure cylinder are side by side, and the small low-pressure cylinder is tandem with the high-pressure, and works on the same crank, the object being to increase the ratio of expansion, and equalise the power of each crank. It is claimed that, in consequence of the narrowness of these tractors, a low-pressure cylinder of the requisite area cannot be placed alongside the high-pressure cylinder. When the starting cock for admitting high-pressure steam into the low-pressure cylinder is opened—to give the maximum power for emergencies—the engine immediately works as a double-cylinder engine, the high-pressure cylinder being converted for the moment into a differential cylinder, the two low-pressure cylinders working as in a double cylinder engine with full boiler pressure. Further, the arrangement provides for double the number of exhaust blasts in the chimney, and therefore ensures a better draught and brighter fire, at the same time further reducing the noise of the exhaust. The pistons are of wrought steel, with Rowan's piston rings. The crank shaft is of special construction, having excentrics and balance weights formed solid with the shaft; thus a high speed of rotation is possible, all the motor parts being enclosed in an oil bath. The brackets carrying the crank shaft and second motion shaft are formed in one casting, the bottom portion of which—together with the side frames of the engine—forms an oil-tight casing for the motion work, allowing for splash lubrication. The valve motion is on the Walschaert principle, the excentric tumblers being formed solid with the crank shaft. The road gearing is arranged for two speeds—two to three miles per hour and four to five miles per hour. The engine is mounted on Fowler's spring gear, and the differential gear can be locked by the driver from the footplate. The boiler has a fire-box of the Belpaire type, and the steerage is of the usual worm type with adjustable chain working on a circular path on the front axle. Messrs. Fowler also show their well-known steam ploughing tackle and heavy road locomotives.

Robey and Co., Limited, show a new light tractor with a single steam cylinder 6in. by 9in. The principal features of note in this engine are the large diameter boiler with short tubes, and a new system of spring mounting of the driving axle, which is very easy of access. This engine is designed for a working pressure of 150 lb., and has two speeds, which can be changed in a simple manner. The driving wheels are 4ft. 9in. in diameter. Marshall, Sons, and Co., Limited, Gainsborough, have as usual a very attractive display, including a 10in. by 24in. long-stroke horizontal engine fitted with Marshall's trip gear, which has equilibrium double-beat valves for both the inlet and exhaust valves; a 10 horse-power independent compound engine fitted with Hartnell's governor and automatic expansion gear; a high-speed vertical engine with a cylinder 7¾in. by 7in. with piston valves and suitable for driving dynamos; a 7 nominal horse-power traction engine with three speeds; and an 8 horse-power portable engine of the firm's latest type, having a

flat base to the cylinder, bolted to plain steel girders and riveted to the top of the fire-box. There is also a stay between the cylinder and the crank shaft bracket. Portable and stationary oil engines are shown by Blackstone and Co.; Campbell Gas Engine Company, Limited—which also shows a suction gas plant; Crossley Brothers, Limited, with a suction gas plant; Fielding and Platt, Limited; Richard Hornsby and Sons, Limited; J. and F. Howard; J. B. Petter and Sons, Limited; Ruston, Proctor and Co.; H. P. Saunderson and Co., Limited; C. F. Wilson and Co.; Fairbanks, Morse and Co.; Alfred Dodman and Co., Limited; and Glover and Sons, Limited, Warwick. E. R. and F. Turner, Limited, Ipswich, show a new high-speed grinding mill, which has been designed to meet the demand for a cheap machine to reduce to a fine soft meal comparatively large quantities of wheat, maize, and other grain. Where a high grade of flour is not required to be made, this mill is claimed to answer the above requirements. The stones working horizontally, as in the ordinary slow-speed stone mill, much more regular and even grinding is obtained—especially after the bearings have become worn—than is produced by high-speed mills with vertical stones. The stones can also be quickly opened out for re-dressing. The mill is made in three sizes, with stones 20in., 24in., and 30in. diameter. The average speed of the 24in. size shown at Islington is 450 revolutions per minute. The machine is belt driven, and runs very quietly, owing to the absence of toothed gearing.

In the 7 nominal horse-power single-cylinder traction engine shown by Messrs. Clayton and Shuttleworth a new feature has been introduced in the shape of a steam feed pump to replace the ordinary force pump. This new arrangement possesses a number of advantages, not the least of which lies in the fact that the pump, being fed by a separate pipe direct from the boiler, is thus rendered entirely independent of the working of the engine. A duplicate feed, for use in case of any emergency, is also provided by means of an injector.

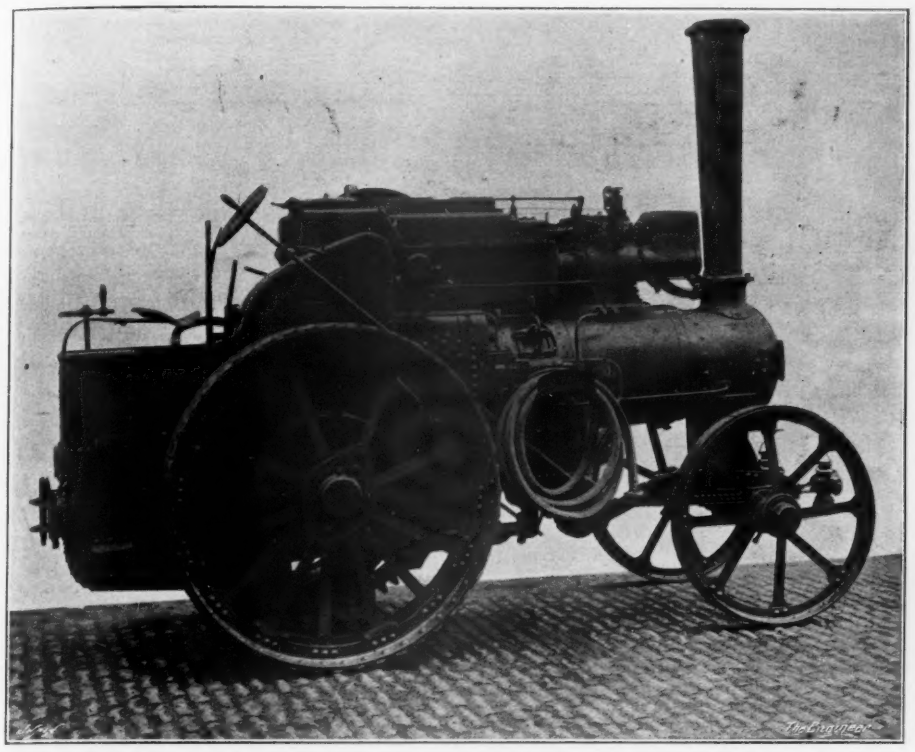


Fig 1—FOWLER'S COMPOUND 5-TON TRACTOR

This firm also shows a light steam tractor of the single-cylinder type, which is exceptionally strong, and has been specially designed and constructed to withstand the heavy wear and tear associated with the use of this class of engine, and two finishing thrashing machines. The most notable introduction is the new type of shaker boxes, which practically double the amount of shaking the straw receives in its passage from the drum. Another novelty is the new adjustable cavings riddle, the mesh of which can be instantly varied, by means of a thumb-screw, to suit any kind or size of grain, thus avoiding the usual loss of time in changing riddles. There is also included a new patent rotary corn screen, the wires being of a new section, which, whilst retaining all the old advantages, is grooved on the inside in a manner that enables the spiral adjusting springs to be still more firmly and compactly fixed to them.

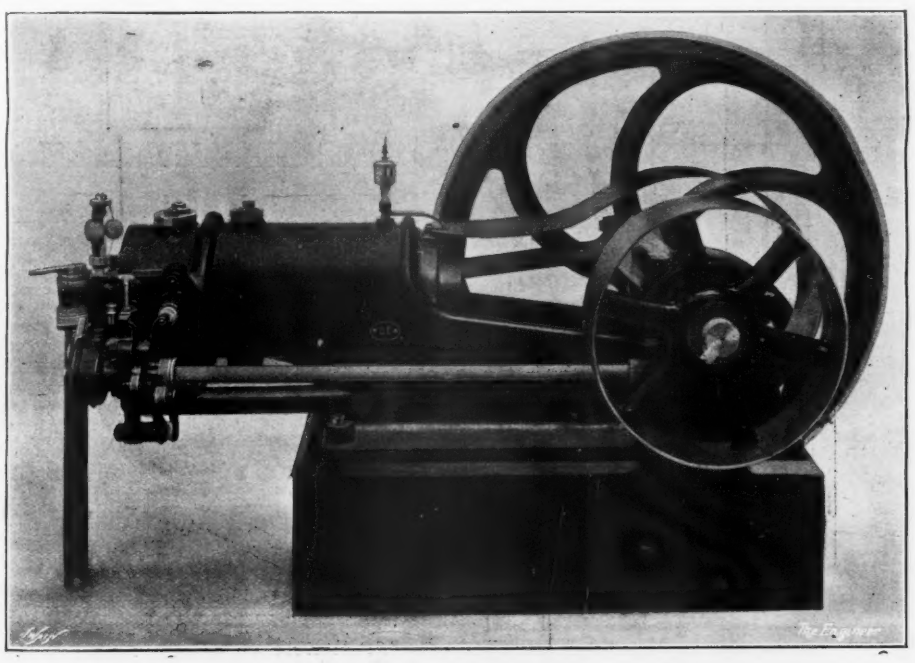


Fig. 2—RUSTON PROCTOR'S 12 HORSE-POWER GAS ENGINE

The illustration given in Fig. 2 shows a 12 horse-power gas engine made by Ruston, Proctor and Co., Limited, of Lincoln. The engine develops 10 to 12 brake horse-power. The cylinder is 8in. diameter by 14in. stroke, and the normal speed is 240 revolutions a minute. It is governed on the hit-and-miss principle. For economical reasons high compression has been adopted, and ignition is effected by means of a low-tension magneto. The timing of the spark can be regulated whilst the engine is running, to compensate for the quality of the gas the engine is using.

A gas producing plant shown, suitable for this size of engine, comprises a generator scrubber, and usually, although not in this case, an expansion box. The vaporiser is contained in the generator, and the bottom of the latter, which is slightly concave, also contains a little water. This, it is said, has the effect of allowing the generator doors to be opened for a short while without affecting the running of the plant; for the red-hot cinders dropping into the water cause steam to be generated, and this subsidises the steam drawn from the internal vaporiser. There is no movable grate. The fire-bars are each separate, so that, should one be worn, it can be replaced easily. A special valve has been introduced between the generator and the scrubber to prevent any gas from diffusing back into the generator when the plant is idle, thus removing all possibility of an explosion from this source. Another feature of the plant is the complete closing in of the drain box, and thus no objectionable odour, it is said, can be detected. The gas is cleaned and cooled in an ordinary coke scrubber with a rose sprinkler. Baffle plates are fitted in front of the opening, through which the gas is drawn off to the engine, to prevent any of the water spray being carried with it.

OBITUARY.

HUGH KIRKBY PEACE.

THE death is announced of Mr. Hugh Kirkby Peace, which took place at his home, Springfield House, Sandygate, Sheffield, on the 10th inst., at the age of sixty-one, after an illness of some duration. Mr. Peace was the head of a well-known and highly esteemed family, which has been prominent in the Sheffield steel trade for very many years, the trade mark having been granted as far back as 1710. The firm—W. K. and C. Peace, Limited, Eagle Works—are manufacturers of crucible steel, files, saws, edge tools, &c. Mr. H. K. Peace, who was the only son of the late Mr. W. K. Peace, J.P., of Moor Lodge, Sheffield, was born in Sheffield on April 3rd, 1845. Educated at Wesley College, Sheffield, and at Neuwied-on-Rhine, Germany, he entered the family business as a young man, and on his father's death became chairman and managing director of the private limited company into which the business was converted. He has occupied the positions of president of the Sheffield File Manufacturers' Association, and member of the Council of the Sheffield Chamber of Commerce.

SOCIETY OF ENGINEERS.

THE fifty-second annual general meeting of the Society of Engineers was held on Monday, December 10th, at the offices of the Society, 17, Victoria-street, Westminster. The chair was occupied by Mr. Maurice Wilson, President. The following gentlemen were duly elected by ballot, as the Council and officers for 1907, viz.:—As president, Mr. Richard St. George Moore; as vice-presidents, Messrs. Joseph William Wilson, William Henry Holttum and George Abraham Goodwin. As ordinary members of Council, Messrs. John Aird, Joseph Bernays, Francis George Bloyd, Alexander Graham Drury, George Green, John Kennedy, Edward John Silcock and Diogo Andrew Symons; as honorary secretary and treasurer, Mr. David Butler Butler; as honorary auditor, Mr. Samuel Wood, F.C.A.

The President announced the death, on November 30th, of Sir Edward James Reed, K.C.B., who was elected an honorary member of the Society in 1877.

The President announced that the following premiums had been awarded by the Council for papers read during the past session, viz.:—The President's gold medal to Mr. Frank Latham for his paper on "Harbour Exigency Works." The Bessemer premium of books to Messrs. W. Pollard Digby and Henry C. H. Shenton for their joint paper on "The Prevention of the Bacterial Contamination of Streams and Oyster Beds"; a Society's premium of books to Dr. David Sommerville for his paper on "The Chemistry and Bacteriology of Potable Waters"; and a Society's premium of books to Mr. Gerald O. Case for his paper on "Submarine Groyning." A vote of thanks was accorded to the scrutineers, and the proceedings terminated by a vote of thanks to the President, Council, and officers for 1906, which was duly acknowledged.

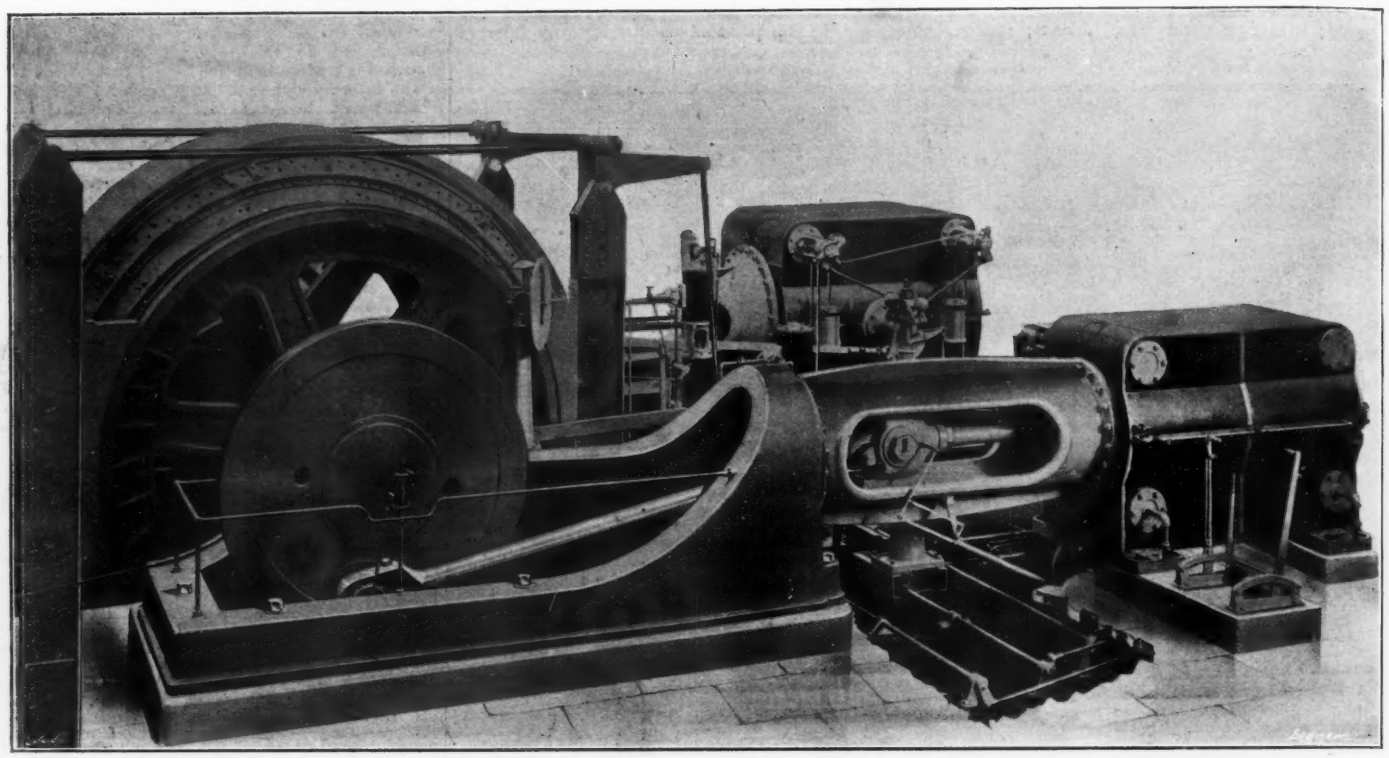
An enjoyable evening was spent on Wednesday last at the Hotel Cecil on the occasion of the annual dinner of the Society of Engineers. Some seventy members and guests sat down to the dinner, which was followed by an excellent musical entertainment. There were a number of speakers, among the principal being Sir Alexander B. Kennedy and Dr. R. T. Glazebrook. The success of the evening was largely due to the excellent arrangements made by the secretary, Mr. Perry F. Nursey, to whom a hearty vote of thanks was passed by acclamation at the end of the evening.

THE INSTITUTE OF SANITARY ENGINEERS.—The annual dinner of the Institute of Sanitary Engineers was held on Monday last at the Holborn Restaurant, under the chairmanship of the president, Mr. E. G. Coker. After the loyal toasts, Sir William Mather proposed "The Institute of Sanitary Engineers," and the President and Mr. G. W. Chilvers replied. "Kindred Societies" was submitted by Dr. J. C. Thresh, and replied to by Mr. W. Whitaker and Mr. A. J. Martin. The toast of "The Visitors" was given Mr. W. J. Dibdin, and replied to by Mr. Baldwin Latham and Mr. C. J. Millis.

FRENCH EXTRA-PARLIAMENTARY COMMISSION ON AUTOMOBILES.—The Secretary observes, in a communication to the *Matin*, that the present racing cars have no relation as regards construction to automobiles of utilisable type, the realisation of excessive speeds requiring arrangements which would become defects in a vehicle intended to last. Recently the record speed was such that it would attain 180 kiloms.—or nearly 112 miles—per hour if it could be maintained; and a maker of steam motor cars claims to have obtained 212 kiloms., or 131 miles an hour. Speed competitions should be suppressed, if only for favouring the evolution of the automobile, already commenced; and constructors should turn their attention to the diminution of shocks when running over paved or bad roads, by the suppression of vibration in the motor, by the long life of the mechanism, and by diminished consumption, added to a variation of compressions permitting the same motor to give out 3 horse-power or 20 horse-power at will.

WINDING ENGINE AT SHERWOOD COLLIERY

FRASER AND CHALMERS, LIMITED, ERITH, ENGINEERS



TEST OF A MODERN WINDING ENGINE.

By DAVID A. BREMNER, M.I. Mech. E., M.I.E.E., M.I.M.M.

THE following analysis of tests of a modern winding engine is based on figures and facts received of a very interesting test which they recently carried out by Messrs. Fraser and Chalmers on a compound non-condensing winding engine of their construction at the Sherwood Colliery. As it is very seldom that the conditions at a mine permit of an accurate test being made of hoisting engine steam consumptions, no doubt the results of the test referred to will be of interest to engineers. Messrs. Fraser and Chalmers carried out the test, with the assistance of the management at the Sherwood Colliery, but the results have been worked out by myself independently. The steam consumption test was made during four days, commencing July 9th, 1906, with the engine in the condition in which it had been running for several months.

The engine is a cross compound type, with high-pressure cylinder 32in., low-pressure cylinder 53in., stroke 66in., designed to work at a steam pressure of from 120 lb. to 150 lb. and to be suitable for condensing, but also capable of working non-condensing also. The drum is of a special design, to suit the winding conditions. These conditions provide for winding 4½ tons of coal per trip and for making eighty trips an hour. To meet these conditions the drum is made 12ft. at the outer ends, on which are wrapped seven working coils of rope. From this the rope rises upon a cone on which there are 2½ coils, the larger diameter being 16ft., on which the remainder of the rope is coiled. To obtain the maximum output of eighty trips per hour, it was intended to use also a balance rope which would still further increase the acceleration and increase the retarding effect at the end of the wind, but as the maximum output has not yet been required no balance rope is as yet employed, and the number of working coils on the 12ft. part of the drum is 4¼.

Fig. 1 shows a plan of the two winding engines, Nos. 1 and 2, with all the steam pipe connections and boilers. A perspective view of the No. 1 engine is shown above. It is of the Corliss type, and has a reheater and steam receiver placed between the high-pressure and low-pressure cylinders, with a throttle valve immediately before the high-pressure cylinder and another one immediately before the low-pressure cylinder. These valves are opened and closed simultaneously by the same hand lever, so that the pressure is always maintained in the receiver, and under ordinary winding conditions no live steam from the boilers is admitted to the low-pressure cylinders. The engine, during the test, was running non-condensing, the exhaust steam going direct to the atmosphere, and the cylinders were steam jacketed.

The engine is fitted with the Whitmore brake, and the landing of the cages on the dogs is done entirely by the brakes—*i.e.*, the reversing lever is not used in any way to manipulate the engine. The cut-off on both cylinders is controlled automatically by the speed governor. On starting up, both cylinders take steam full stroke, and when up to a certain speed the latest cut-off comes in, which is about 40 per cent. of the stroke, and the cut-off is decreased until the speed rises to the maximum, at which speed the engine continues to run until the throttle is closed. The rope employed is of the lock coil type, 1·675in. diameter. The cages are double-deck, having three trams on each deck. They are guided in the pit by ropes, and are particularly steady. The loading and landing of tubs is done simultaneously on both decks. The time for changing tubs from stop to start is frequently as short as 8 seconds. The landing dogs are of a special type, which can be withdrawn without having to lift the cages. This arrangement, of course, saves time.

The boilers are of the Lancashire type, 9ft. diameter by 30ft. long. There were two boilers used, and at the time of the trials both were hand-fired. There are in all four boilers, and the arrangement of main steam pipe is such that steam going to the power-house, fan engine, &c., leaves at one end, and at the opposite end there is a tee piece with a Hopkinson valve connected to each branch. One branch is the steam main leading to the No. 2 pit engine, the other to the No. 1 pit engine, which is the compound referred to.

Precautions were taken to catch any water and condensed steam that would get to the valve leading to the No. 2 engine main, and practically nothing at all passed the valve. To separate the Nos. 1 and 2 boilers that were employed for working the winding engine during this test a blank flange was inserted in the main between the second and third boiler. The feed-water piping arrangement was such that with the two pumps employed, by inserting a blank flange in between No. 2 and No. 3 boilers, one pump could be used to deliver water to the two boilers for the winding engine, and the other pump to No. 3 and 4 boilers. The feed pumps were driven by the steam from No. 3 and 4 boiler, and, therefore, were not included in the test. By this arrangement we were unable to use the economiser for the winding engine boilers, and so these boilers were supplied with water at the ordinary supply main temperature.

Superheaters are fitted immediately behind each boiler, and were in operation during the test. The temperatures given in the table are the averages of the thermometer readings close to superheaters during each test. It was found impossible to get any useful record from the readings of the thermometers in the steam chest of the high-pressure cylinder, since steam was only admitted to the cylinders during about 23 seconds in each trip, thus the thermometers were only exposed to the full temperature of the steam during that time; the rest of the time they were exposed to steam at a pressure of between 30 lb. and 40 lb.—*i.e.*, the receiver pressure.

The test was running continuously from 7.10 a.m. on July 9th to 2 p.m. on July 11th, 1906; but as the main object was to obtain the steam consumption of the compound winder only, it was necessary to have a series of short tests, during which periods No. 2 winder was not required by the colliery, and it was possible to cut out the steam main leading to it. A coal consumption test and feed-water observations were also taken for the whole time.

Tests Nos. 2, 3, and 4 were run under the ordinary working conditions of the colliery, making about 33 trips per hour. This, of course, is much below the proper capacity of the engine, as the colliery is not yet fully developed. During

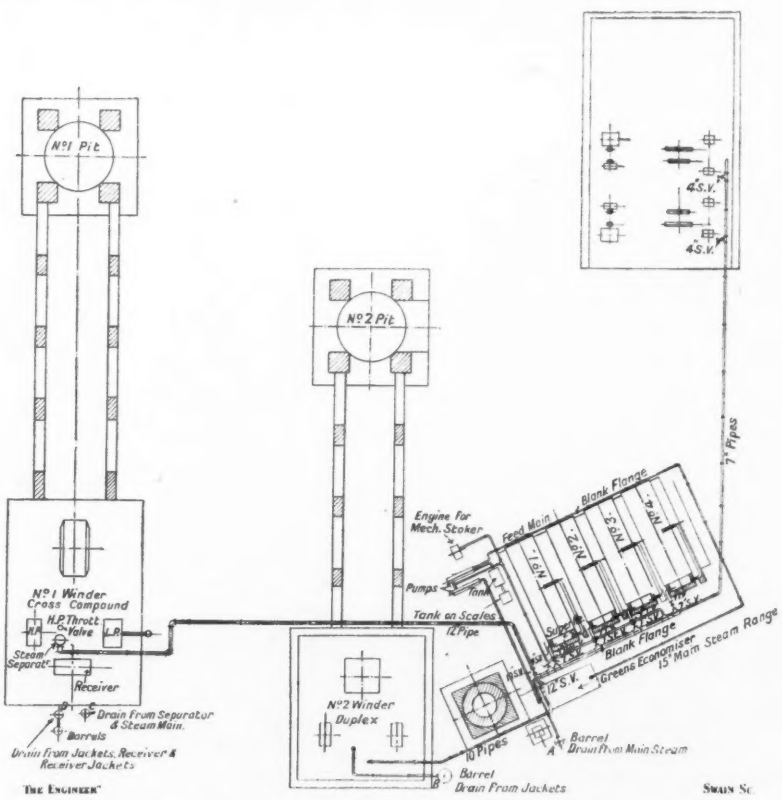


Fig. 1—WINDING EQUIPMENT AT SHERWOOD COLLIERY

the night before the fifth test as much coal as possible was collected at the pit bottom, and arrangements made to make the output during four hours—6 a.m. to 10 a.m.—as large as possible, in order to be able to test the steam consumption of the engine at as near full load conditions as possible, and an average of 58·5 trips per hour was obtained.

Fig. 3 shows the number of trips made per half-hour for both No. 1 and No. 2 winder throughout the whole period of the test, from 7 a.m. July 9th to 2 p.m. July 11th. It will be seen that there were certain periods during which it was possible to cut out No. 2 winder entirely, and thus obtain short tests from four to six hours each on the compound winder alone.

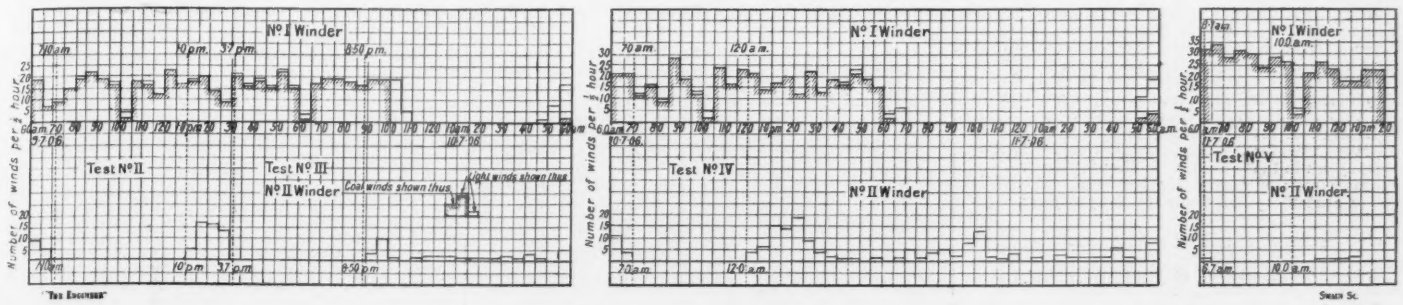


Fig. 3—NUMBER OF TRIPS OF BOTH WINDERS PER HALF-HOUR

The method of weighing the water was by means of two tanks. One tank, holding about 233 gallons, was placed upon previously corrected scales. Accurate weights were employed, and the water supply was controlled by means of a valve immediately over the top of the tank. This tank delivered its water to a larger tank below, the suction pipe of the feed pump being attached to the bottom of this tank. The tank on the scales was filled and the weight noted accurately every time, and allowed to run quite empty before starting to refill.

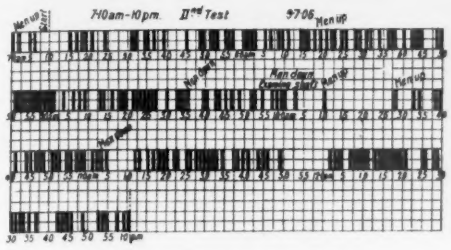


Fig. 4—DETAILS OF WINDS

Preparations for the test were all completed on July 7th. July 8th—being Sunday—it was possible to take the steam consumption of that part of the colliery while standing, so as to arrive at the steam and coal consumption due to condensation in the mains, &c. This part, however, had little or nothing to do with the compound engine test, but, since arrangements were provided for testing, it was a matter of useful information for the colliery company. This was test No. 1.

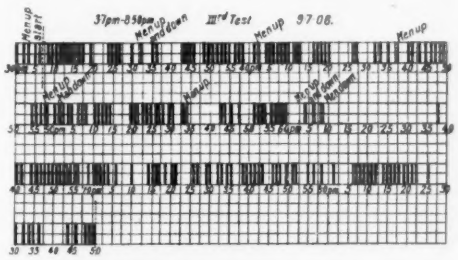


Fig. 5—DETAILS OF WINDS

This test was taken with No. 1 boiler only in operation, and with all jacket valves, &c., on the No. 1 winder only opened up, *i.e.*, in a condition to start winding at any moment.

To carry out each test as accurately as possible the compound engine was indicated simultaneously at both ends of both cylinders, and two to five diagrams were taken on each card. The first set was taken from the start to the end of the second revolution, the second set being taken from the second to the end of the fourth, and so on. At least two complete sets of cards were taken, running over and under during each test.

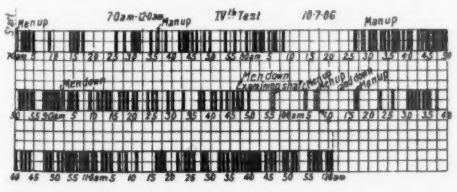


Fig. 6—DETAILS OF WINDS

During each period the time was taken at the commencement and at the end, and the various speeds noted on a tachometer. At each pit bank assistants were appointed solely to note the exact contents of the landed and downgoing cages. As a check for this they had the colliery tram checker's books, from which the average weight per tram was taken. There were steam traps provided to catch any water that might have accumulated in the steam main, receiver, cylinder jackets, and water that might leak into the branch of the No. 2 engine. Each of these steam traps delivered its water to separate tubs. The traps were all in fairly good working condition. Readings were taken of the jacket water discharged into these tubs during the test, but they are not given in detail, as they are all included in the steam consumption figures.

One assistant, whose duties have been described above, was in constant attendance at the feed-water tanks. Another assistant was in charge of the boiler-house, and at the commencement of each test noted the height of the water in the four gauge glasses of the two boilers, which was maintained as closely as possible at this height all the time, and at the end of the run any difference was recorded. He had also to pay special attention to the safety valves and the steam pressure. The coal test was going on at the same time, and he also kept a record of the coal. Another assistant was deputed to record the temperature of the steam immediately after the superheaters, and in the steam chest of the high-pressure cylinder, also in the low-pressure cylinder, and the temperature of the feed water. Tests were also made with a calorimeter on the steam separator, close to the high-pressure throttle, but they all showed dry steam. Readings were made in the boiler-house every ten minutes, so that the records were complete should the trial which was being run stop before the pre-arranged time; in fact, all readings were so carried out that each trial could run for any length of time.

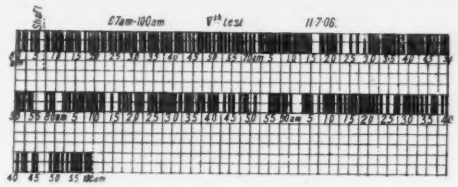


Fig. 7—DETAILS OF WINDS

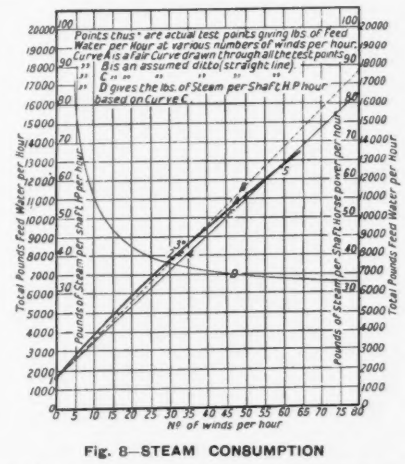

Points thus ° are actual test points giving lbs. of Feed Water per Hour at various numbers of winds per hour.
Curve A is a fair Curve drawn through all the test points
B is an assumed ditto (straight line).
C " " " " "
D gives the lbs. of Steam per Shaft H.P hour based on Curve C.
Total Pounds Feed Water per Hour
Pounds of Steam per Shaft H.P per hour
Pounds of Steam per Shaft Horse power per hour
Nº of winds per hour

Fig. 8—STEAM CONSUMPTION

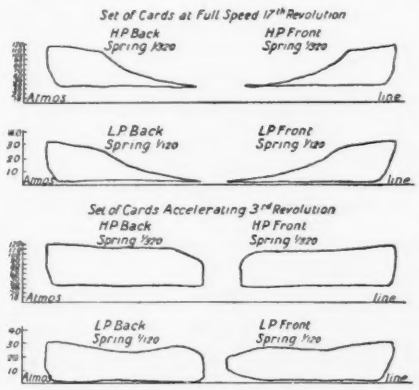

Set of Cards at Full Speed 17th Revolution
H.P Back Spring 1/20
H.P Front Spring 1/20
L.P Back Spring 1/20
L.P Front Spring 1/20
Atmos
line
Set of Cards Accelerating 3rd Revolution

Fig. 9—INDICATOR DIAGRAMS

When the No. 2 winder had to be in operation, the important trials of the No. 1 were stopped, and readings for the combined windings were duly recorded. These, however, I am not concerned in. The part which will, I consider, be interesting to your readers concerns only the steam consumption of the compound winder.

Fig. 4 is a chart of the number of winds and the contents during trial No. 2; Fig. 5 shows a similar chart for trial No. 3; Fig. No. 6 for trial No. 4; and Fig. No. 7 for trial No. 5. On each of these charts is given the duration of the test, which was the longest possible time that could be arranged under the present-time working conditions of the colliery.

In the following table is given the number of the tests in the order in which they were taken, with the principal particulars and results, including the steam per shaft horse-power per hour during each of these separate tests:—

Number of test.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Duration of test in minutes	135	350	343	300	233
Total number of trips, including men, raised or lowered	—	196	193	168	227
Total number of trips, allowing men raised only as ·8 of coal trip	—	190·4	190·6	164·8	227
Average number of trips per minute	—	0·544	0·556	0·55	0·974
Average coal hoisted, lb. per trip	—	9,314	9,318	9,229	9,428
Depth of wind in feet	—	1,332	1,332	1,332	1,332
Average shaft horse-power	—	204·5	209	205	371
Boiler gauge pressure	135	125	130	125	130
Superheat at boilers in deg. Fah.	—	70	65	65	105
Mean speed of hoisting, seconds per trip	—	40·4	39	40	38·7
Percentage actual running time of total time	—	36·7	36·2	36·7	63
Weight of steam delivered by boilers during test	5590	47,501	48,608	40,988	48,884
Weight of steam delivered by boilers per hour	1720	8,142	8,500	8,198	12,588
Ditto per shaft horse-power hour in lb.	—	39·82	40·7	40·0	33·95

Several trips were made during tests 2, 3, and 4, winding or lowering men. From inspection of the indicator cards taken under these conditions, it was estimated that roughly about 80 per cent. of the steam was used that would be taken during an ordinary coal-winding trip, so to obtain the total number of trips in each test, 0·8 was added to the number of coal trips for every such light load when men were raised, but the trips lowering men were neglected; these are given in the diagram of windings. No such allowance had to be made during No. 5 test, as all the trips were made with the full load. As stated above, the exact analysis of the trips in each test is given in Figs. 4, 5, 6, and 7.

From this table the curve has been plotted—see Fig. 8—which gives a close approximation to the steam consumption that may be expected at other capacities. It might be expected that the total steam consumption per hour would be proportional to the number of trips per hour with the addition of a constant for condensation losses. This would mean that the five points representing the tests should lie on a straight line. It will be seen that this is not quite the case in the present instance—see curve A—since a straight line B through points 1, 2, 3, and 4 passes somewhat above point 5. This may be accounted for in the following way:—During tests 1, 2, 3, and 4, the joint on the main steam separator close to the engine was blowing rather badly. This became decidedly worse during No. 4 test, so the engine was shut down during the night preceding the fifth test, and the joint re-made. Another point is that a considerably greater superheat is obtained during test No. 5, which should reasonably cause a smaller consumption of steam per wind. I think that the above taken together fully account for the deviation of the curve from a straight line, and tests 2, 3, and 4 thus serve as a very useful check on the accuracy of test No. 5.

I have also plotted a steam consumption curve D based on a straight line C drawn through points 1 and 5, and from this it will be seen that at a greater capacity of the engine, say 75 to 80 trips per hour, a steam consumption down to below 33lb. per shaft horse-power per hour may reasonably be expected even without the addition of a balance rope. This output will be obtained in the future when the working faces of the colliery are extended.

During these trials, including test No. 5, the engine was run with the throttles wide open until about the 20th revolution. From this point the engine ran to bank with very little braking, the cone drum, of course, having a great effect. The average time of each trip was practically the same during all the tests.

There is one point about this particular plant which tends somewhat to reduce the efficiency, and that is the largeness of the cages. There are two decks, with three tubs on each, and it can easily be imagined, when travelling at high speed, the superficial area of these decks in contact with the air in the shaft has a great retarding effect. It may be well to mention that what I term "shaft horse-power" is the average coal load per trip hoisted, multiplied by the depth of the shaft in feet, multiplied by the average number of trips per minute divided by 33,000, and the steam consumption referred to is the amount of water that is passed into the tank from which the feed pump draws its water.

All jacket water is included in the steam consumption, and I may point out that as the actual water delivered to the feed pumps has been taken as the basis of the figures, any leaks that may have occurred between the measuring tanks and the exhaust pipe of the engine are all debited against the engine.

Specimen diagrams are given in Fig. 9, the full steam cards being taken at about the third revolution from the start, and the out-off occurs at about the seventeenth when up to full speed. Each set of four cards is taken simultaneously.

The steam consumption results of this compound winder are especially interesting when compared with the steam con-

sumptions obtained in a test on a compound condensing winding engine made by Messrs. Fraser and Chalmers for the Rand mines. This test was carried out by Messrs. E. J. Laschinger, A. M. Robeson and H. C. Behr, who read a paper on it before the South African Association of Engineers on March 3rd, 1906. Here a very complete test was made, and it will be found on considering the conditions of the two plants—viz., the Johannesburg plant running, condensing, and hauling from a greater depth—2290ft.—with light cages; and the Sherwood engine, hauling from a much less depth, running non-condensing and with very heavy cages—that the actual steam consumption of 33·95 lb. of steam per shaft horse-power per hour compares well with the 25·5 lb. of steam per shaft horse-power per hour obtained in the Johannesburg test, especially as the Johannesburg tests were taken on condenser discharge and jacket water drained off so that no possible leaks are included in the figures. A further point is that the Johannesburg engine was running for 65·98 per cent. of the time owing to special tipping and filling arrangements for the skips. This is a larger percentage than those given in the tables for the Sherwood test.

Both these tests will probably be found to establish records for condensing and non-condensing engines respectively.

GRAVING DOCK CONSTRUCTION.

On Wednesday, December 5th, Mr. J. F. Ramsbotham read a paper before the Liverpool Engineering Society dealing with the construction of graving docks generally, and with the methods followed in the construction of the new Brocklebank graving dock at Liverpool in particular, full details of these being given in the paper as printed. According to the author, the new Brocklebank graving dock, which occupies the site of the old Brocklebank wet dock, possesses the following special features:—(1) The pumps are driven by gas engines; (2) the walls are plumb, with cut away altar-courses at the top and steel and concrete for the lower altars, the latter being 2ft. wide; (3) the gates are steel of abnormal size, having 141ft. 8in. centres; (4) the pumps are used also for impounding purposes for pumping the wet dock up to a higher level on neap tides.

During the construction of the dock the plumb walls and altar-courses were adversely criticised by those who were going to use the dock, but the author states that time and experience have proved these criticisms to be unfounded.

The engine-room equipment was supplied by Messrs. Tangye, of Birmingham, and comprised two main gas engines of Crossley's make, of 510 horse-power each, running at 140 revolutions per minute, and two 48in. centrifugal pumps. Gas from the mains of the Liverpool United Gas Company is used for running this pumping machinery, and the graving dock can be emptied in a little over three hours by the pumping plant.

The gates are built of steel, each leaf weighing 230 tons. The centres of the heel posts of the gates are 141ft. 8in., and the sill is in two segments, the lower sides of the gates being 90ft. radius. Each leaf of the gate is divided into six decks, two of which are water-tight. The pivot on which each gate moves is made of cast steel with a spherical top 21in. radius, and 2ft. 2in. diameter. The rollers are likewise made of cast steel, and are 3ft. 6in. diameter and 16in. wide. The gates were built by the Tranmere Bay Development Company, at Birkenhead, and were entirely completed on the slipway before launching. They were launched on a spring tide, floated across to the Liverpool side of the Mersey, and sunk by opening the valves in the lower compartments until the gates reached the perpendicular position in the dock entrance. They were then stepped by aid of the 100-ton floating crane Atlas. By building and completing the gates in this way, a great deal of money was saved, but very careful setting out work had to be carried out as a preliminary by those responsible, in order to obtain a successful result.

The author in his paper dealt also with the following points:—Setting out, pumping, excavation, drainage, setting heel stones, entrance and sill, dredging, blocks, and trials of the pumps.

In an appendix a completed list of the Liverpool and Birkenhead graving docks is given; this shows nineteen docks, with a total length of floor of 13,497ft.

INSTITUTION OF ELECTRICAL ENGINEERS.—On Tuesday evening 4th inst., the annual dinner of the Institution of Electrical Engineers was held at the Hotel Cecil, under the chairmanship of the President, Dr. R. T. Glazebrook Some 400 members and guests sat down to the dinner, and among those present were Sir Norman Lockyer, Lord Justice Buckley, Mr. Babington Smith, secretary of the General Post-office, Sir W. de W. Abney, and Sir Arthur Rücker. After the usual loyal toasts had been duly honoured, Mr. Babington Smith proposed the toast of "The Institution" in an interesting speech in which he alluded at some length to the progress made by wireless telegraphy. The President responded. "Science and Industries" was proposed by Lord Justice Buckley, and replied to by Sir Arthur Rücker. Col. R. E. Crompton proposed the toast of "The Visitors."

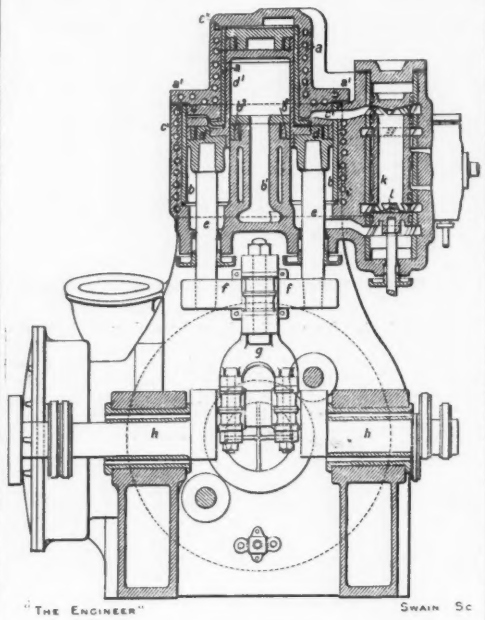
LEEDS ASSOCIATION OF ENGINEERS.—The forty-first annual dinner of the Leeds Association of Engineers was held at the Queen's Hotel on the 1st inst., when Mr. E. Kitson Clark presided over a large company. The Lord Mayor—Mr. Joseph Hepworth—being unable to attend, his place was taken by the Deputy Lord Mayor—Mr. Robert Armitage. Following the loyal and patriotic toasts, Mr. Henry Barran, president of the Chamber of Commerce, gave the toast, "The City and Trade of Leeds." Mr. Armitage, in responding, congratulated the Leeds University on having opened a new department, which would be directly concerned with the economy of fuel and fuel gases. In England a large amount of fuel was wasted daily. In blast furnaces and coke ovens particularly valuable gases which might be put to profitable use were allowed to escape. In Germany, on the contrary, where coal was dear, a great deal of attention was paid to the subject, and he hoped that in a short time Leeds would set an example to the whole of this country in the matter. Again, neither Germany nor America had any stock of pig iron, and both were drawing very largely upon the only stock in the world, which was held by this country. But our stock was weekly becoming less, and as a consequence users in this country were having to pay more for their raw material. As Englishmen, they did not, of course, like to see their country denuded of this important commodity. They would like to see work put on it here, so that it could be sent away in a more or less finished state. In other countries pig iron was rarely sent away as raw material. The metal went direct to the various steel furnaces in the neighbourhood, thus avoiding the cost of remelting. In this way our foreign rivals had a distinct advantage over a great many places in England. Concluding, he hoped that some of the large pig iron makers in this country would get attached to them steel works, by means of which the raw material could be turned to better account.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

PERKINS' BOILER.

SIR,—In your report of the adjourned meeting of the Institution of Mechanical Engineers, which appeared in your issue of the 7th inst., you, on referring to the remarks I made at the meeting on the Perkins boiler, quote me as follows:—"Whatever kind of water was used there was no incrustation." May I venture to



PERKINS' ENGINE

explain that I have no recollection of making this remark. I believe I said—certainly I intended to say—that, "so far as my experience went it was free from any trouble due to corrosion or incrustation." As a matter of fact, an important feature of the Perkins system was, that all the water put into the boiler to supply the loss by leakage of the engine glands, &c., was distilled from fresh water.

Perkins' later boilers were a marked improvement on the one shown in your most interesting diagrams. A good idea of their general arrangement, as I remember them, can be formed by an examination of the patent specification No. 2819, October, 1871, which I enclose herewith. HENRY J. SPOONER.

The Polytechnic School of Engineering,
December 10th.

A CENTRIFUGAL PROBLEM.

SIR,—It is not surprising that your correspondent "A. B. C." has had conflicting opinions from his friends as to the ingenious problem propounded in your issue of November 30th; but it is strange that your correspondents of last week should be unanimous in declaring the feat to be impossible. All of them seem to have missed the real point at issue, for I do not imagine that "A. B. C." supposed that the mere relative motion of the sphere and the cyclist could of itself produce a force which would counteract that acting on the cyclist due to gravity. A wheel or disc held against the highest point of the interior of the rotating sphere would obviously lose none of its weight, whether rotating itself or not. But it has apparently been overlooked that in the case supposed by "A. B. C.," the cyclist is doing mechanical work, and the question appears to be whether the force he exerts can by any means produce a force acting against gravity. Now, assuming the cyclist to be at the top of the rotating sphere, it is obvious that the effect of his muscular effort is to tend to move him in a straight line tangential to the sphere at its highest point, *i.e.*, to increase his distance from the centre of the sphere, from which it appears not so impossible that if the speed be great enough his hazardous position, like that taken up by "A. B. C., may yet be a tenable one. X. Y. Z.

December 10th.

SIR,—I see that the ingenious person who started this problem has been sufficiently dealt with by several correspondents last week, and I shall not help to expose his obvious mistake. May I, however, introduce another problem based on the same or a similar apparatus? We all know the moving belt travelling in one direction with horses, cyclists, or walkers trying to move in the opposite direction, but, of course, remaining at rest. Take the case of a motor cyclist doing this. Does his engine have to perform any work beyond the small amount consumed in the internal friction of his machine? I say it doesn't. Now take the problem a step further. Incline the belt and let the cyclist start to ride up it. When he has got to a certain point, let his speed in one direction be equal to that of the belt in the other. He, of course, comes to rest. Is his engine doing any work in this case? L. S. D.

December 12th.

BODMER'S BALANCED LOCOMOTIVES.

SIR,—I have lately acquired a number of working drawings of John George Bodmer's balanced locomotives. The drawings are dated from 1844 to 1847. The prominent features of the engines are double reciprocating pistons in each cylinder, four cranks, and cylindrical slide valves. Some engines have outside cylinders and others inside. The drawings are all numbered and dated, but, unfortunately, there is nothing on them to show the names of the railways for which the engines were built.

Possibly some readers may remember these engines, or have some records of their general appearance and dimensions. If so, and they will communicate them through your columns, an interesting section of locomotive history can be recorded. Without information, all I could do would be to publish the drawings, with the bald statement that they were "Bodmer's engines," which would be unsatisfactory from the historical standpoint. H. T. W.

December 4th.

LEVEL BOOKS.

SIR,—With regard to Mr. Alexander's letter in your last issue, giving a well-known system of entering levels, I may say that level books ruled half for this method and half for the "rise-and-fall" method can be obtained from A. G. Thornton, Paragon Works, King-street West, Manchester. F. C. COOPER.

December 8th.

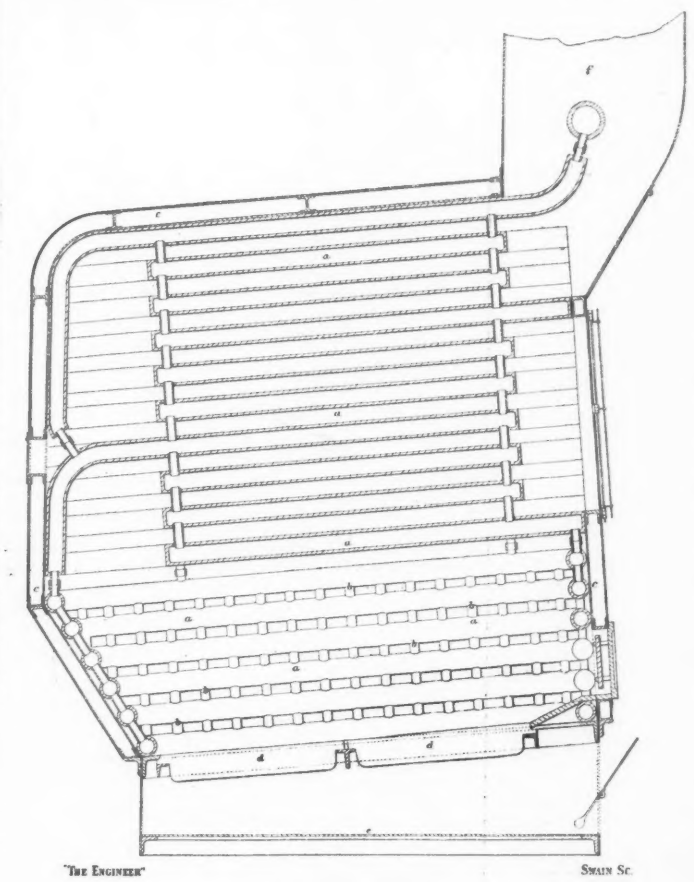
FOG SIGNALLING.

SIR,—In your able article in last week's ENGINEER respecting the inquest on a driver and fireman who lost their lives owing to collision during a fog, you speak of our antiquated system of fog signalling, and we specially note your remark, "That if a good apparatus was brought out it would be universally adopted."

Now, Sir, we have devised a mechanical fog signalling apparatus, which has been inspected by two skilled signal inspectors who are in the service of large railway companies, and they both admit that our apparatus is undoubtedly the simplest, cheapest, best, and least likely to get out of order of any invention of its kind that they have ever seen. But, Sir, you say a good apparatus would be universally adopted. Well, ours is acknowledged good, also simple, cheap, and the best they had seen. But we, and the representative of a good firm who were present thinking of taking up the patent, were informed that at a conference of engineers and signal inspectors they were generally agreed not to recommend any mechanical system of fog signalling, no matter how good, even if it would do everything that could possibly be required. Under no circumstances could or would they recommend any mechanical device for fog signalling.

If that is the spirit in which signal inspectors are going to report on the merits or otherwise of any system introduced other than manual, inventors waste their time devising such apparatus. ASTONISHED.

December 11th.



PERKINS' BOILER

THE ENGINEERING AND SCIENTIFIC ASSOCIATION OF IRELAND.—An ordinary general meeting of the Association will be held at the Royal College of Science, Stephen's Green, on Monday, 17th December, at 7.45 p.m. Paper, "Navigation," Captain H. G. Quirk, F.R.A.S. On Saturday, 15th December, the annual smoking concert will be held at the Gresham Hotel, 7.45 p.m.

INSTITUTE OF MARINE ENGINEERS.—Lord Pirrie, President of the Institute of Marine Engineers, was present recently at a Bohemian concert given at the Institute premises, 58, Romford-road, E. In the course of the evening Lord Pirrie presented to Mr. Robert Mackenzie the "Denny" gold medal, which had been awarded him for his paper on "A Three-stage Collecting and Compressing Machine for CO_2." His Lordship then presented the prizes which had been given by Mr. A. E. Battle for the best essays written by graduates of the Institute on a visit to the Engineering Exhibition at Olympia. The prizes had been awarded to two young engineers, Mr. Walter Smith and Mr. William Wallace Adamson.

RAILWAY MATTERS.

THE total length of railways open in France in 1905 was 23,815 miles. The gross earnings amounted to £62,469,320, compared with £60,072,440 in 1904, or an increase of £2,396,880.

THE first place in the awards for the season just closed for the best-kept platform gardens on the Midland Railway is shared by Malvern Wells and Eckington, Worcestershire, and the second by Matlock Bath and Five Ways, near Birmingham.

IT is said that there are 819 miles of electric railway in operation in Michigan State. The Detroit United Railway leads with 279 miles, and the Michigan United, which includes lines out of Lansing, Kalamazoo, Battle Creek, and Jackson, comprises 151 miles. There are 83 miles of electric roads surrounding Grand Rapids, 87 in the Detroit, Ypsilanti, and Ann Arbor line, and 66 in the Detroit, Monroe, and Toledo system.

IN view of the electrification of the Berlin City Railway, tests are being carried out on an experimental railway constructed near Berlin, oval in shape, and 1736 m. in length. It is supplied with single-phase alternating current at 6000 volts by overhead wires, and traffic is conducted day and night. Records are being kept of various materials used in the construction of the track and of the work of the electric motor cars.

IN a despatch to the Foreign-office, relative to the Austrian Budget estimates for 1907, H.M. Embassy at Vienna report that the revenue returns of the current year exceed those of last year by £2,600,000. The increase of revenue estimated for 1907 is to be devoted in part to the development of railways and agriculture, secondary education, and an increased subsidy to the Austrian-Lloyd. The telephone system is also to be extended.

THE Erie Railroad Company has ordered three of the largest engines ever built. These locomotives are of the Mallet articulated compound type. Each will have sixteen driving-wheels, which will bear all the weight of the engine, thereby securing the advantage of every pound of the 410,000 lb. weight. The boiler, says *Iron Age*, is over 8ft. in diameter at its largest part and contains 2¼in. tubes to the number of 468. The tender carries 8500 gallons of water and 16 tons of anthracite coal.

EXPERIENCE with electric railways in Italy has been so favourable that it is now proposed to make a more extended use of this source of power, and instead of replacing the old rolling stock with new locomotives in some regions, the lines will be operated by electricity. During the past three years 260 miles of electric railways have been operated in Italy, including the Milan-Gallarate-Varese line, 80 miles, which is operated by the third rail, and the Valtellina, with 65 miles of electric line, using overhead conductors.

TWO recent passenger train wrecks, caused by failure of the brakes to work, have been attributed to the closing of an angle cock in the brake pipe, thus cutting out the air brakes on the rear cars. The *Railroad Gazette* states that the evidence seems to show that in both cases the closing of the angle cock was accidental and not due to carelessness or malicious tampering. Such accidents are a rare but not unknown danger which has baffled the efforts of railroad men and inventors for twenty-five years.

AN important new project under survey by the Jodhpur and Bikaneer Railway is the Borawar (or Degana) Hissar line, metre gauge, 180 miles in length, which will probably supersede the Kuchaman-Sirsa proposed chord between the Durbar system and the Southern Punjab Railway. The line will be 180 miles in length if it starts from Borowar, and 190 miles in length if Degana is the point of departure. The line will be entirely within the Durbar's territory, and will connect Rajgarh, Churu, Sujangarh, and Didwana.

SIR CHARLES OWENS recently strongly condemned the attacks made on railway companies for not running third-class sleeping cars; and suggested that, instead of an extra fee being charged for these cars above the ordinary first-class tariff, a separate ticket should be issued to cover the journey and the extra accommodation. There would then be no question of class at all. He stated that the British charges for sleeping berths were very low, compared with prices for similar accommodation in the United States or on the Continent.

ACCORDING to the *Railway News*, the French Government will apparently proceed with the Bill for the State purchase of the Western Railway. The measure originally presented by the Minister of Public Works has undergone important changes under the pressure of the committees of the Chamber, which have suppressed the clauses providing for purchase by voluntary agreement. If the purchase of the line is voted by the Chamber, and ratified by the Senate, the working of the Western line will thus be immediately undertaken by the State.

THE earnings of the New South Wales railways and tramways for the quarter ended September 30th last showed a considerable increase over those of the quarter ended September 30th, 1905. The revenue from railways was £1,054,619, compared with £997,007; the expenditure rose from £604,420 to £622,488. The mileage of lines opened increased by 87, and now amounts to 3390¾ miles; and the train miles run were 2,960,673, an increase of 109,626 miles. The earnings per train mile were 7s. 1½d., and the expenditure 4s. 2½d. The earnings per tramcar mile amounted to 1s., and the expenditure 9¾d.

TRICHINOPOLY can fairly claim to be the Clapham Junction of the South Indian Railway, but its rival cheroot city is well on the way to contest the title. The latest project of the Madura District Board is Dindigul-Uttamapalaiyam, on the Vaigai Valley Railway project, 72 miles metre gauge, which was the subject of a concession granted to a company in 1901 and abandoned by it in 1905. Another new District Board project for Tanjore is the Nidamangalam-Vedaranien line, which will strike the coast at the latter port a few miles north of Point Calimere. The company has been authorised to carry out a survey of an alternative alignment strongly recommended by the District Board.

THE *Anglo-Japanese Gazette* states that the German-built engine has gradually crept into favour in Japan. In 1905 the imports of locomotives from Germany increased nearly six times, as compared with 1904. The United States also trebled its imports under this class, while the United Kingdom fell off to third place. This preference for German and American locomotives can only be accounted for on the score of cheapness, German prices being 25 per cent. under those quoted by British makers. For the American article the advantage claimed is that orders are executed with much more promptitude than is the case with orders for British locomotives. The Sanyo Railway Company employs only American locomotives, but finds it to its advantage to order axles and wheels from Germany.

THE report of the Victoria Parliamentary Standing Committee on Railways on the Proposed Electric Street Railways for Melbourne and district states that six electric street railways were recommended for construction by Mr. F. E. Bradford, who was appointed by the Victoria Government to advise the committee, the united cost of which was estimated at £228,124. The committee, after prolonged researches, have come to the conclusion that, with one possible exception, none of the projected lines would be able to pay its expenses. In the single case exempted from the general condemnation—that of a line from Prahran railway station to Malvern—the committee recommended that the earning capacity of the line should first be tested by running motor omnibuses along the route, "under similar conditions as regards service, fares, &c., as the suggested electric street railway."

NOTES AND MEMORANDA.

DURING October last 57 heavy motor vehicles were registered in the County of London, bringing the total up to 1110, as against 12,456 pleasure motor cars, and 6448 motor cycles.

CORK forests exist in several parts of Morocco, and when order is established, and the cost of transport is lessened by the construction of roads and bridges, these forests may well be turned to profit.

THE cost of working a steam omnibus service in Torquay seems to have been steadily reduced. The cost has diminished from 11·19d. per mile in the first year to 8·88d. per mile in the third year.

TWENTY-TWO people were killed by motor vehicles, including motor omnibuses, during last year in the metropolis, compared with 116 who came by their death through accidents due to horse-drawn carts, vans, and omnibuses.

A SHORT time ago there was cast in a Milwaukee foundry a single casting weighing 133 tons. This, it is believed, is the largest single piece ever cast in America. To handle this huge mass of metal, special cranes and derricks had to be provided.

THE first electrical power derived from Niagara Falls for the use of Toronto was available for use on the 19th inst., and will be used for lighting and power purposes of all kinds. The present amount available is equal to that of 40,000 horse-power.

FOR 1905 the output of sheet mica in the six producing States of North Carolina, Colorado, New Hampshire, Georgia, South Dakota, and New Mexico, amounted to 851,000 lb., having a total value of £38,728. North Carolina leads in production, having an output of 170,200 lb.

EXPERIMENTS made with the German cruisers Luebeck and Hamburg, the former using turbines and the latter piston engine, have, it is said, proved the superiority of the turbines, but they showed at the same time certain disadvantages, as the turbines were unable to stop quickly enough when going at full speed.

ACCORDING to figures o the Census Bureau, the capital invested in American manufacturing establishments in 1904 amounted to approximately £2,537,253,135, this figure indicating an increase for five years of 41 per cent., while the gain in the products of manufacture has been 30 per cent., the 1904 aggregate being £2,960,429,417.

AT the wireless telegraphy station, recently erected by the De Forest Company at the instigation of the Newcastle Chamber of Commerce, at Cullercoats, the first message was received on the 4th inst. The communication came from the steamer Helene Blumenfeld, which was then 80 miles from Cullercoats, on a voyage from Hamburg to the Tyne.

THE celebrated Hungarian chemist Brumm claims to have discovered a liquid chemical compound which renders certain kinds of matter proof against the effects of time and the elements. He claims it will double the density of nearly every kind of stone and render it waterproof. It is said to impart to all metals those qualities which resist and defy oxygen and rust.

LIGNITE in gas producers is reported by Mr. H. Neumann in the *Zeitschrift* of the Society of German Engineers to be giving satisfactory results when the gas is cleaned. For example, at the 250 horse-power plant of the Kalk Chemical Works a 321-hour test of a 70 horse-power generator was made, corresponding to a run of 1½ months, and only a very thin soot layer on the exhaust valve resulted, causing no trouble in working. Brown coal briquettes were used.

THE copper district of the French Congo is said to be very extensive, ore having been discovered over a wide area. It has long been known that at 300 kilom. from the coast there is a rich copper-mining centre, not far from the Free State, where trenches and rudimentary shafts indicate a primitive working in the past. The deposits can be reached direct from the coast, or from Boma, the Belgian Congo port, with the Mayumbe Railway, the terminus of which is 150 kilom. from the mining fields, or from Brazzaville. The Knilu Niari River flows through most of the country, and is navigable except in places.

LARGE electric motors for rail-mill driving have been ordered by a steel company of Chicago, Ill. These motors will be used in the rail mill. Among them are two 2000 horse-power motors operating at 214 revolutions per minute; one 2000 horse-power motor operating at 88 revolutions per minute; and three 6000 horse-power motors operating at 88, 83·3, and 75 revolutions per minute respectively. The three 2000 horse-power motors are rated at 3000 horse-power each for one hour, with a temperature rise of 60 deg. Cent., and the three 6000 horse-power motors are rated at 9000 horse-power each for the same length of time and temperature rise.

ACCORDING to the *Architect and Contract Reporter*, the longest concrete arch yet undertaken anywhere is that of the main span of the Walnut-lane bridge in Philadelphia, which also has the third place in the list of long span arches of all classes of masonry. The structure, which is now in process of construction, consists of one main arch having a clear span of 233ft. with a rise of 73ft., and five other arches each having a clear span of 53ft. The total length of the bridge is 585ft. The bridge is designed for highway traffic, and carries a 60ft. street at a height of 147ft. above the creek. The five approach arches are all semicircular in form, and each has two ribs or rings resting on twin shaft piers.

ARRANGEMENTS have been made for founding in New York city an institution to be known as the New York Observatory and Nautical Museum. They originated at the New York Yacht Club, and several of the wealthiest members are pledged to subscribe to a fund to carry the plans into effect if the necessary charter can be obtained from the State Legislature, and the city authorities will agree to provide suitable buildings in Bronx Park. If the arrangements are carried out, the city will have a first-class observatory, which will be at the service of the public two or three nights a week, and a nautical museum, containing models of all existing types of vessels, signal devices, nautical instruments, and historic relics, which will attract the public, and be of educational value.

THE behaviour of iron under weak periodic magnetising forces formed the subject of a paper read before the Physical Society recently by Mr. J. M. Baldwin. The behaviour of iron in strong alternating fields has been studied by many observers, and the induction in iron when placed in both strong and weak fields has been thoroughly examined by static methods, but up to the present no results have been published of the induction in weak alternating fields. The author has now, however, succeeded, by means of Lyle's wave-tracer, in examining the induction in periodically varying fields down to extremely low amplitudes. The principal points brought out are as follows:—(1) The permeability satisfies a linear law through a considerable range for weak fields, diminishing to a minimum about 150 as the amplitude of the field diminishes; (2) as the field diminishes the difference in phase between the induction and the magnetising force tends to disappear, and (3) at the same time the hysteresis losses become very small; (4) frequency at these low values of the field has practically no influence on the results obtained.

MISCELLANEA.

IT is reported that new and very rich deposits of manganese have been found in the vicinity of Michailowka, a village close to the station of Carayagni, in the government of Elisabethpol, Russia.

THE thirty-two widows whose husbands were killed in the explosion at Wattstow Colliery, Rhondda, in July, 1905, have received from the owners £7000 in excess of the sums payable under the Compensation Act.

WEST Ham Town Council has decided to urge upon the Government the claims of the Thames with regard to naval shipbuilding contracts as a means of alleviating distress due to the alleged scarcity of shipbuilding work.

THE *Journal de St. Petersbourg* states that the Russian Mercantile Marine Council has reported that improvements are urgently needed at the following ports:—St. Petersburg, Libau, Windau, Archangel, Odessa, Batoum and Astrakhan.

A WORK of some magnitude is to be carried out at Devonport Dockyard. A dam is to be built by the Superintending Civil Engineer's Department across the entrance to the North Dock, and when this is completed new dock gates are to be built and fitted.

AN immense irrigation scheme for watering 1,358,000 acres of rich agricultural land in the Murrumbidgee Valley, New South Wales, has passed the Legislative Assembly. The Government intend to establish a close settlement area of intense cultivation.

IN Africa the telegraph service frequently suffers interruption because of giraffes becoming entangled by their necks in the wires. Elephants, too, are at times responsible. This disturbance, says the *Export Implement Age*, has occurred on the Victoria Falls line six times.

COMMANDER PEARY, in a lecture which he recently gave in New York, said he was satisfied that there was land somewhere 100 miles to the north-west of Grant Land. He had found driftwood in the open Polar sea, which he was convinced came from rivers flowing through an unmapped land.

MANCHESTER, we understand, is to have its garden city. The promoters of the movement have secured the option of purchase of an estate of between 700 and 800 acres within five miles from central Manchester, and if the purchase is decided upon it is proposed to establish a city with accommodation for 30,000.

A POSSIBLE industry of the future is the manufacture of sugar in Morocco, of which there is a large consumption in that country, 657,182 cwt. having been imported last year. Though sugar cane could, perhaps, not be grown in many districts, there would appear to be no reason why beetroot should not be successfully cultivated.

AN electric automobile and cab line is being talked of by Buffalo business men. It is proposed to provide a system of sight-seeing cars to be used in the summer months in taking Buffalo visitors through the city and its parks and to Niagara Falls; also to provide a line of small cars to run between the trains, boats, and hotels.

A RETURN was presented at a recent meeting of the City of London Corporation showing that, compared with electric light, incandescent gas had effected a saving of £490 in the annual lighting bill of one area. A resolution was thereupon passed that certain electric light standards in the streets be removed and incandescent gas lamps substituted.

THE Russian Minister of Marine, in an official statement, shows the necessity of constructing a fleet of large warships without retarding the construction of the flotilla of small vessels and submarines already approved. He recommends the immediate construction of two battleships of the Dreadnought type, at an estimated cost of £2,100,000 each.

VICE-ADMIRAL VON EICKSTEDT, Director of the Construction Bureau of the German navy department, recently announced at a meeting of the Technical Shipbuilding Society that the German navy intended to use turbine engines in the future. Admiral von Eickstedt said he was authorised by Admiral von Tirpitz, Secretary of the Navy, to state that he intends to use turbines as much as possible.

WE learn from *Indian Engineering* that of the three most important wants of Bombay, viz., sufficient water supply, disposal of the sewage, and the provision of over-bridges on the railways, relating to the health and comfort of the inhabitants, probably the one most urgently calling for attention is the second. It is satisfactory to know that the project for the effective disposal of the sewage has at last been sanctioned by the Corporation.

FROM statistics recently issued it is interesting to note that the total number of motor cars which paid the tax in 1905 in France was 21.523, with an aggregate of 179,361 horse-power, of which 45,346 horse-power belonged to the Department of the Seine, the number of cars being 4627, would give an average of nearly 10 horse-power per vehicle. In the remaining departments the number of motor cars was 16,896, with a total of 134,015 horse-power.

THE correspondent at Melbourne of the Board of Trade—Mr. H. P. Wollaston—reports that arrangements are well forward at Broken Hill for a scheme to provide a supplementary water supply for the mines and the municipality, at an estimated cost of from £150,000 to £175,000. The Corporation is to apply to Parliament for the necessary powers, and the mines are to find the money. The latter have appointed Mr. T. W. Fowler to report on the whole proposal.

THE commission appointed to report on Italian ports has submitted to the Minister of Public Works a scheme for the improvement of nearly 100 ports, and of the lights on the coast during the years 1907-17, the total expenditure being placed at about £7,200,000. The estimate does not include the cost of railway extension which will be needed at some ports. If the proposals of the commission are sanctioned, the total expenditure on these works during the ten years will amount to £10,000,000.

THE Moorish Government before the signature of the Algeciras Act had granted concessions to a German firm for the construction of harbour works at Tangier and Laraiche, and to a French firm for harbour works at Dar-al-Baida and Saffi. A report from the British Consul at Morocco states that as yet, however, work has only been commenced at Tangier, where a new mole is in course of construction. It is expected that works at the other ports will not be begun until next year. In course of time, as the necessary funds become available, tenders will be invited for various public works in the way of harbour works, roads, and bridges.

THE greater facilities granted to Europeans for acquiring land may lead to the establishment of new industries in Morocco. An experiment in sericulture, conducted during the last few years by an Englishman at Tangier, has met with success, and shows that silk of fine quality can be produced, the principal difficulty experienced having been the acquisition of enough suitable land for the cultivation of the mulberry trees necessary for the silkworms, for though under the Madrid Convention of 1880 the right of foreigners to purchase land was recognised, it has hitherto proved nearly impossible to acquire land except in the immediate neighbourhood of Tangier, where the quantity obtainable is limited and the price very high.

THE GREAT NORTHERN, PICCADILLY, AND BROMPTON RAILWAY

(For description see page 598)

Fig. 7—KING'S CROSS STATION PLATFORM

Fig. 8—FINSBURY PARK CROSS-OVER

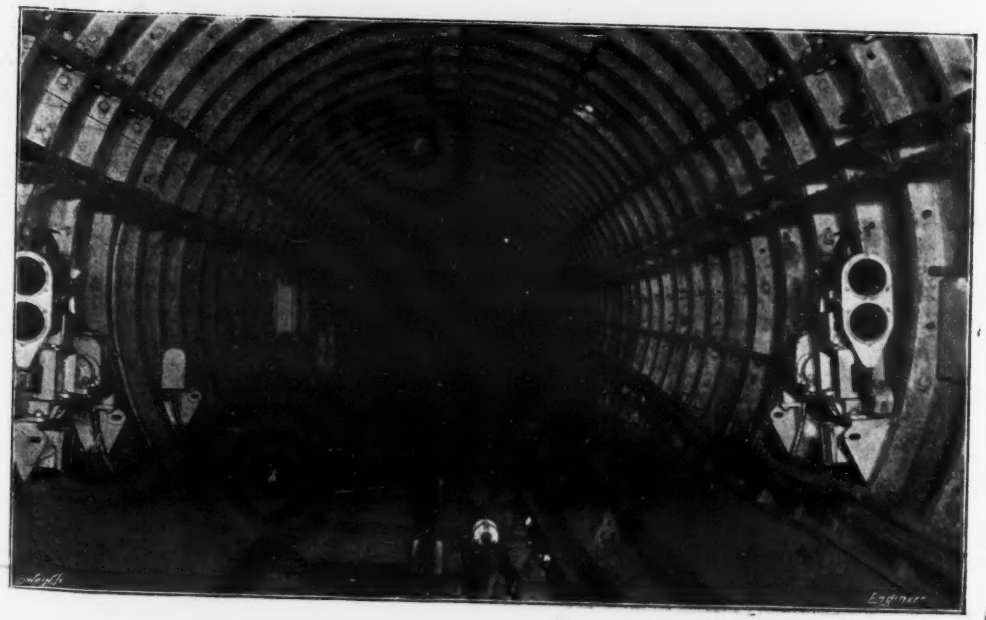


Fig. 9—STRAND JUNCTION SIGNALS AND TRIP

Fig. 10—HYDE PARK CROSS-OVER

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

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REPLIES.

R. J.—We cannot find any particulars of the Albini gun mounting. Are you thinking of the Albini rifle, a small-arm?

T. D.—You could not persuade the water to go in the direction you propose. It would rise from below as freely as it would fall from above, and a state of rest would soon be reached.

W. B.—We gather that you want a book dealing with the care and management of boilers rather than their construction. If that is so, see "Steam Boilers, their Management and Working on Land and Sea," by James Peattie, fifth edition, published by Spon, 1906. A good general book on steam boiler design and construction is Hutton's, published by Crosby Lockwood.

MEETINGS NEXT WEEK.

INSTITUTE OF MARINE ENGINEERS.—Monday, December 17th, at 8 p.m., at 58, Romford-road, Stratford, E. Paper or discussion.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 18th, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Discussion, "Mechanical Considerations in the Design of High-tension Switch Gear," by Henry William Edward Le Fanu, M. Inst. C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 20th, at 8 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Ordinary general meeting. Paper, "The Track Circuit as Installed on Steam Railways," by H. G. Brown.

ROYAL METEOROLOGICAL SOCIETY. Wednesday, December 19th, at 7.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Papers: "The Guildford Storm of August 2nd, 1906," by Admiral J. P. Maclear, F.R.G.S. "The Metric System in Meteorology," by Richard Inwards, F.R.A.S.

SOCIETY OF ARTS.—Monday, December 17th, at 8 p.m., at John-street, Adelphi, London, W.C. Cantor Lectures: "Artificial Fertilisers, their Nature and Functions," by A. D. Hall, M.A., Director of Lawes' Agricultural Trust. Tuesday, December 18th, at 8 p.m. Applied Art Section. "Basket Making," by Thomas Okey. Wednesday, December 19th, at 8 p.m. Ordinary meeting "Modern Developments of Flour Milling," by Albert E. Humphries, President of the Incorporated Association of British and Irish Millers.

THE ENGINEER.

DECEMBER 14, 1906.

Suction Producer Trials.

IT is safe to say that not for many years has the Royal Agricultural Society conducted a series of trials which has roused more general interest than those held at Derby in June last on suction gas producers and engines suitable for agricultural purposes. The entry was good, twelve makers sending engines, and the public not only showed their interest at the time, but has continued to show it by repeated applications for the report during the last few months. This report is now public property; it was presented at the meeting of the Committee of the Royal Agricultural Society on Wednesday last, and part of it appears on pages 608 to 611 of the present number of THE ENGINEER. It was hoped at one time that its publication might have taken place much sooner, but this and that unavoidable delay occurred. Those who complain of the long interval between the awards at the trial and the appearance of the report must bear in mind that it is the usual custom of the Society to include the accounts of trials in its *Journal*, which does not appear till the spring following the show. They may also recall that in one instance—that of the Newcastle trials of portable engines, if we remember rightly—the report did not appear till nearly two years after the tests!

As it is impossible in one issue to print the whole of the report, we have divided it into two parts, and have taken the second, which includes all the results and tables, first. In these tables the first column to which attention turns is the consumption of fuel per horse-power produced. These will be found in Tables IV., V., and VI., and it will be seen that in the eleven plants of which complete figures are given, the consumption per brake horse-power at full load varied between 1·04 lb. and 1·48 lb.; at half load between 1·38 lb. and 1·98 lb., and at full load with coke between 1·21 lb. and 1·65 lb. The smallness of the consumption of fuel for plants of such limited size—the biggest developed little more than 20 horse-power—has been so frequently insisted on that it need not be discussed; but we may notice that whilst between the best plant and the worst the difference is less than half a pound of coal, the difference among the better plants themselves is almost insignificant, amounting to no more than ·05 lb. On the half-power trial, the difference between the best plant and the worst—not, by the way, the same engines as in the full-power tests—was ·60 lb., and that between the three best only ·11 lb. Turning, finally, to the coke trials, the same figures are ·44 lb. and ·12 lb. When these small differences are translated into fractions of a penny—the standard by which the user will judge the economy of his plant—they become insignificant, and might be readily counterbalanced by other facts—the initial cost of a plant, the credit given, the upkeep, and so on. Whilst, then, it will be admitted that, for scientific purposes, and for the purpose of making a definite award, the figures are useful, it must be acknowledged that there is very little difference, as far as economy is concerned, between the better suction gas plants; and a purchaser, in selecting which amongst the four or five best plants he shall buy, may, for all practical purposes, almost leave the question of economy out of account. Capital cost will, no doubt, in many instances be the decisive factor, and the inclusion in Table I. of the price of the plant per horse-power is a valuable feature. The differences in this table are remarkable. The most expensive plant is priced at £17 10s. per brake horse-power; but as this includes an exceptional engine, it does not afford a correct basis for comparison. The next plant is £13·55 per brake horse-power, which may be taken as the highest. The lowest is £8·82. The winners of the awards priced their plants at almost the same figure, £11·65 and £11·77 per brake horse-power, and this seems to be, from the remaining figures, about the proper price for a trustworthy plant; two plants, however, which did excellently in the trials, were entered at £10 per horse-power. No doubt, a considerable discount is allowed on these figures; but taking it that the percentage is approximately the same in all cases, they form a very useful basis of comparison for the purchaser. Price was one of the points which the judges took into consideration in making their award, but in what way we are not told. A fact which has been too generally neglected in suction gas trials is the consumption of water, and we are glad to find definite figures in the present report. Taking the full power, that with anthracite, Table IV., it will be seen that one engine received only three-quarters of a gallon per brake horse-power, whilst another took as much as 3·61 gallons. These appear to be extremes, but there is, nevertheless, a very marked difference in the water consumption of the two best plants, one consuming 1·14 gallons and the other 2·45 gallons per brake horse-power. Whilst it is certain that in many cases the consumption of water is not a matter of much importance, in others it is an item of some weight, and it is a little startling to find that a gas engine requires about as much water to run it as a steam engine. The question of water economy is clearly one that will stand further investigation. The fact that the plant to which the highest award was given consumed considerably less than half the water required by the plant receiving the second award, shows that there is considerable scope for improvement in this direction. It may be noticed also that a plant consuming only 1·09 lb of fuel per brake horse-power took the least water, ·98 gallons. In view of the fact that a portable suction producer plant is required, the importance of improvements in the scrubber, which will reduce the water consumption, is manifest.

We shall reserve certain interesting points for later discussion, but on one general aspect of the trial we must touch now. We have already shown that the differences between the better plants is extremely small, and we cannot but feel that to make the awards must have been a matter of some difficulty. The fact seems to be that the scale of the awards is too great for the differences in the merits of the competing plants. The step between a gold medal and a silver medal, and between a silver medal and nothing, is not in proportion to the differences in the results, and it is suggested, with a good show of reason, that it would in such cases be better to classify the plants than to make awards to particular competitors. Thus, for example, all plants having a less consumption than 1·1 lb. might be in the first, all plants consuming less than 1·2 lb. in the second, and so on. This is a suggestion that seems worth consideration on another occasion. It is clear that whilst the judges must have found the figures of material assistance in arriving at a decision, they must have been influenced considerably in their judgment by other facts, no less important than fuel consumption, connected with the plants. We trust also that longer tests may be possible in future. In Paris a fortnight is now being devoted to experiments of this kind. That is better, but even it is too short to find out all that might be found by a prolonged run. Unfortunately the obstacles in the way of such tests are enormous, and it would only be at an exhibition open for many weeks that they could be adequately carried out, and only then at great

expense. On the whole the Royal Agricultural Society has done admirable work in instituting these trials, and the excellent report by Captain Sankey will be found of material value both to the makers and users of suction gas producers.

London Electricity.

TUCKED away at the end of the bulky publication which the London County Council goes to the expense of printing each week for the information and edification of its members and others possessed of a spirit of inquiry is a document entitled, "Report of the Finance Committee (No. 2) on the London County Council (Electric Supply) Bill, 1907." This Report deserved a more prominent position, for it not only contains words of warning, but it offers to the Council a way of escape from the position which it had taken up regarding this attempt to obtain powers to "supply electric energy in London and certain surrounding districts," to use the exact words of the Report. In a former pronouncement by the Finance Committee, dated 30th October last, they stated that they had not then had time fully to consider the important proposals, and that they only then dealt with the broad financial issues involved. Since that time they have carefully considered the matter. It is pointed out that the scheme provides for the ultimate purchase by the Council of the undertakings of the electric lighting companies and local authorities within the area. This, however, will not take place till 1931, and it is argued that the liability for capital expenditure under this head is not a matter of present concern. Perhaps it is not, saving in so far as it is laying a burden on posterity which they will not care to take up. The Finance Committee pass over this matter with a light touch. They do not think it necessary, or indeed possible, they explain, to attempt to estimate the extent of the liabilities which may be incurred by the Council in the future in connection with the purchase of these undertakings; but, they add, "It is obvious that the development of the Council's scheme in this direction, whenever it takes place, must involve the raising of large additional capital." Then comes the following statement, of which anyone who has been connected with electrical undertakings will appreciate the full significance:—"So far as the outlay upon the new system of generation and supply is concerned, however, the amount and rate of progress and expenditure may be to some extent beyond the Council's control, inasmuch as the Council will be under obligation to make provision for meeting all reasonable demands for supply."

Discussing other questions that are raised, it is pointed out that interest on capital borrowed has been calculated at an average rate of 3½ per cent. It is very doubtful if the Council will obtain the money at this rate. Then, again, the repayment of debt is provided for, on the basis of cumulative annuities, within the periods of the estimated life of the various parts of the works, the equated period working out at about thirty-two years. What portion, it may be asked, of an electrical supply equipment will not be more than antiquated at the end of thirty-two years? But, as against this, it is put forward that the estimates provide for the setting aside of a renewals fund for the replacement of large pieces of machinery, &c., as they become worn out, while the expenditure on ordinary repairs and maintenance, including small renewals, is to be met directly out of revenue account. How much reliance is to be put on these two statements may be gauged by comparison with what the Council has done in the case of the tramways. Here the appropriation for maintenance and renewals has been manifestly inadequate, and there is no reason to suppose that it will be otherwise with the supply of electricity. The County Council has its ways of dealing with accounts, and it is not likely to forsake them. It is when the question of revenue is discussed, however, that the warning we have referred to is given. The Committee recognise that it is "not possible to frame any certain estimates" of what may be expected. The experts, they remark, show that if all the energy generated is sold, there will be a "small surplus of revenue over all charges when two-fifths of the new generating station are in full operation." This is, presumably, with a 100 per cent. load factor for twenty-four hours a day, which certainly will not be realised. They fear, however, that "during the early years, while the business is being got together, and the undertaking gradually brought into operation, some charge on the rates must be looked for." However, by "1915, or thereabouts, there should be a substantial surplus!" Moreover, "the Council will have the advantage of starting its undertaking with a demand already created in the shape of the tramways." If the scheme is to be started with the tramway load, what is to become of the existing station at Greenwich, on which so much money has been and is being spent? Is it proposed to put all of it on the scrap heap? and if not, why drag it into the question at all?

The Report then goes on to deal with general financial considerations, and at the end we find the following:—"The financial difficulties, to which we have called the attention of the Council, would to a large extent be obviated if the Council saw its way to adopt some scheme . . . . by which the Council, while retaining general control, would be relieved of the responsibility of working the undertaking in whole or in part." If these words mean anything they mean that, in the opinion of the Finance Committee, the Council ought not to embark on the scheme as proposed. Estimates can be shown to prove anything. The steamboats—the reference is trite but apposite—were going to pay handsomely. The electric scheme will certainly not pay just at first. The Committee "fear" this, they say. Others are certain of it. For years the electricity undertaking—if allowed to develop into a reality—will be a millstone round the necks of the ratepayers. If ever it paid, such a scheme would have to be most ably managed. The Council has shown itself incapable of such management. And yet, in face of the warnings given by a section of itself, and in spite of the no uncertain pronouncements which have appeared on nearly every side in the Press, the Council has decided to proceed. We sincerely trust that either by opposition, or by reason of other circumstances, the Bill may never become law. If it does, then we make the following prophecies with every certainty that they will be fulfilled:—So far from there being a "substantial surplus" in 1915, there will be a dead loss; and so far from electricity being cheaper, the Council will never be able to compete in price with a properly-managed private enterprise. The whole affair is simply monstrous, and the Council would have done well, even from its own point of view, and having regard to the future, to take the thinly-veiled advice of its Finance Committee. The loop-hole of escape was offered, and it was ignored.

Work on the Footplate.

AMONG the numerous claims advanced by labour, that of the engine drivers and firemen is not the least interesting. Mr. Bell, the talented secretary of their union, has much to say which deserves careful consideration. He reviews the whole situation in his report presented at the last annual general meeting held at Cardiff on the 1st of October. Mr. Bell said that an enormous increase of traffic had been worked by 1200 fewer engines and sets of men than would have been required on the scale of 1905. "Thus the mental and physical responsibilities of the men generally have been vastly increased, and those of the firemen particularly, who have to shovel nearly double the quantity of coal on the large engines without any extra pay at all. This system of working heavier trains with larger locomotives has been responsible for blocking the promotion of firemen, brakesmen, and other grades." We have just now nothing to do with signalmen or porters, or train hands of any denomination save the drivers and firemen. The demand made is not so much for shorter hours as for more pay. In this there is nothing abnormal. Nothing, indeed, so unusual that it requires more than a passing reference. It is in the reasons advanced by Mr. Bell in favour of his demand that we find matter for thought, and even for doubts that Mr. Bell has made himself master of all the facts.

In brief, Mr. Bell contends that men driving and firing big locomotives should have big pay. He claims, it will be seen, that their responsibilities are greater and their work harder. We gather, indeed, that he looks on the big engine as a mistake, and much prefers piloting. He claims for the big engine a distinct economy in the working of trains, and asserts that the saving effected should, in part, go to the men. We find it difficult to follow him, and we doubt that he speaks with a full knowledge of the whole subject. Let us analyse the arguments advanced, and see how far they are consistent with facts. In order to do this, we must compare the working of a big and a normal express engine. By the first is, of course, meant locomotives of, say, the "Atlantic" type, now used to some extent for working fast heavy trains over long distances.

Now, in so far as the driver is concerned, the work he has to do on the footplate is not in any way affected by the size of the engine. It is true that the more complicated the machinery, the greater the care required in examining it before starting on its day's work. But this does not involve extra labour. Vigilance in looking out for signals and watching his gauges must be the same, whether he is in charge of a little tank engine or a modern monster. There is, of course, the sentiment that because one engine is large and the other small the duties connected with the first are more onerous than those connected with the last. But sentiment does not affect wages. The truth is, however, that the men like to drive the modern powerful engine. They are spared a great deal of worry. The locomotive is master of its work, and keeps time easily. The driver escapes the risk of being fined for unpunctuality. His mind is free of care. He does not see his pressure gauge going steadily if slowly back, as he crawls up inclines which his engine can scarcely climb if the weather is adverse. As we have said, the driver, according to our experience, freely admits all this—in private.

With the fireman the conditions are different. In one way he has work to do the magnitude of which bears a definite relation to the size of the engine. The big engine burns more coal than the little engine, and this coal has to be dealt with by the fireman. He has a grievance; let us see to what it amounts. Take, first, a normal express engine, with a train of 200 tons behind the tender, and timed to make an average speed of 50 miles an hour; such an engine will burn at the most—we must allow the most—40 lb. of coal per mile run, or per hour $40 \times 50 = 2000$ lb. The fireman will have to shovel all this through the fire-door. It does not leave him very much spare time. But a healthy young man, practised in the use of the shovel, finds nothing exhausting about the work. Next consider the case of a six-coupled express of the largest type, with 350 tons behind the tender, and 55 miles an hour schedule time. The consumption will reach 60 lb. per mile, and the quantity to be put through the fire-door every hour will be $60 \times 55 = 3300$ lb., or 53 per cent. more. It does not appear that the smallest difficulty is met with in finding firemen who are quite able and willing to put a ton and a-half of coal through a fire-door hole in an hour. The actual amount of extra labour they can possibly have to perform is represented by handling 1300 lb. or so of coal. But against this must be put the circumstance that, as a rule, they are spared a great deal of trouble. The struggle of a fireman with a boiler that is not making enough steam is sometimes heart-breaking. Mr. Bell makes no allowance for this, because, of course, no difficulty of the kind arises when there are two engines working a train instead of one.

Long non-stop runs constitute another grievance. Very few of these exceed four hours in duration. The quantity of coal to be put into the furnace is, however, the same, whether the train does or does not stop. It is true that an interval occurs in the labour of the fireman while a train is at a station, but he does not do much sitting down. In short, from the time he gets on a footplate until he gets off it he has to work, and that hard. But the extra work brought in by the modern method of hauling trains is very moderate indeed in amount; and is, we believe, paid for, the pay of engine-men on the footplates of the big engines being higher than that of any other enginemen.

If we compare the position of a locomotive fireman with that of a marine fireman, we shall see at once that the former is much better off. The ship's stoker is on duty four hours, and eight hours off—that is to say, he works for about the same time continuously that an express train fireman does. But there is no comparison between the conditions of service. On the railway the man is in the open air. He is not scorched. The temperature in which he works is moderate. Compare a footplate with a stokehold, and consider what a "foretaste of hell" cleaning fires is at sea contrasted with "clinkering" a set of locomotive fire-bars. We do not, of course, wish to argue that two wrongs make a right, but we do maintain that Mr. Bell's case for the men on the footplate is not quite so strong as that clever orator endeavours to make out.

It must be clearly understood that we do not assert that locomotive enginemen get all the pay they are worth. We do not say that their wages ought not to be raised; that is a matter to be settled by their union and the railway companies. We do contend that as far as drivers are concerned they have no quarrel with the big engine. They like it, for the reasons which we have set forth. If there is a grievance it is a fireman's grievance, and we fancy that if all the truth were known it is the firemen, not the drivers, who are agitating. Of course, they are backed up for obvious reasons by the drivers. Done into simple English, Mr. Bell's words mean that he does not like the big engine, or the big train, or the modern methods of working. He appears to see in them all the unrighteous hands of companies who seek their own aggrandisement at the cost of their men. It seems a pity that the attempts of the

companies to improve their methods of working should not find favour with the men. But it may make the companies ask themselves whether, after all, they have been quite prudent in adopting so many American notions on their roads.

The Export of Swedish Iron Ore.

THE interests of pig iron producers in Great Britain in the exports of Swedish iron ore are not so considerable in point of volume as those of their competitors in Germany, although the proposal brought forward by Sweden slightly over a year ago to levy an export duty on the raw material was regarded by importers in both countries with a certain amount of dismay. At the time the attention of the Board of Trade was drawn to the scheme, but it was finally withdrawn on the conclusion of the new treaty of commerce between Sweden and Germany for a period of five years, terminating in 1910. On its part, Sweden gave an undertaking not to impose a duty on the exports of iron ore during the currency of the agreement, while Germany made certain concessions in favour of the former country. It is now urged in iron and steel circles in the Fatherland that the spirit of the treaty in this direction is being violated by endeavours put forward to limit the quantity of iron ore sent out of Sweden from the Kirunavara mines to the ice-free port of Narvik. So serious is the problem regarded for the German iron and steel trade that it resulted in a long discussion in the Reichstag on Friday last, consequent upon an interpellation addressed to the Secretary of State for Foreign Affairs. The extent of Teutonic interests may be illustrated by the statement that they procured 2,500,000 tons of iron ore from Sweden in 1905, whereas the British imports from the same source were only 191,000 tons, and were much less than in the preceding year. It is probable that the reduction in the case of Great Britain is due to our having allowed ourselves to be outstripped or ousted by Germany in Sweden; but, on the other hand, our imports of iron ore increased last year from Spain, Norway, Algeria, and France, although the tonnage obtained from Greece declined in 1905 as compared with the previous twelve months.

The discussion in the German Reichstag on Friday centred around an allegation that the Swedish Government have given an instruction that the railway between the mines and Narvik is only permitted to transport a certain tonnage of ore every year, and that it has therefore been necessary largely to restrict the export since the beginning of November. In the circumstances the Secretary of State was asked what steps it was proposed to take in the matter of effectually coping with a measure inconsistent with a loyal interpretation of the particular clause embodied in the treaty of commerce. It appears that the Grangesberg-Oxelosund Trafikaktiebolag, which is a large owner of the iron ore fields in the north of Sweden, has the right of forwarding by the State Railway to Narvik an annual quantity of 1,200,000 tons of iron ore for export. The company desired to increase the tonnage by 400,000 tons in 1906, and by 600,000 tons in 1907. The Swedish Government declined to sanction the proposal for next year, while agreeing to allow an additional quantity of 300,000 tons for the present year; but even the latter arrangement was subsequently terminated at the wish of the Swedish Parliament. It is under these conditions that a storm of indignation has arisen in interested circles in Germany, in consequence of the alleged interference with the Teutonic supplies of iron ore, and reprisals are suggested as being urgently necessary, one proposal even reviving the scheme for the imposition of an export duty on coal and coke supplied to Sweden. But let us hear what the Secretary of State had to say in reply to the interpellation. Count Posadowsky informed the Reichstag that the Swedish Government, in the first place, concluded an agreement with the Grangesberg Company to transport 1,200,000 tons of iron ore per annum at reduced rates, but as the working expenses of the railway were double those obtaining on the other lines, an increase in the quantity of ore was arranged for; but this was cancelled at the request of the Swedish Parliament, as previously mentioned. The application of the company for a still larger augmentation for 1907 was also refused, on the ground of the terms embodied in the original agreement.

It is instructive to learn on the authority of Count Posadowsky—and the information should be of value in the United Kingdom—that Germany concluded the treaty of commerce with Sweden in the expectation "that no obstacles should be placed in the way of the export of ore to Germany in the interest of our iron industry," that considerable reductions in the German tariff were conceded in that expectation, and that the export question formed principally the essence of the whole of the negotiations in regard to the institution of a new treaty of commerce between the two countries. The inference might be drawn from such a statement that Germany claimed a monopoly of the supplies of ore raised in Sweden, and that no other country has any right to purchase any; but such contentions cannot be admitted for one moment, notwithstanding the financial interests assumed by certain banks in one or two Swedish mining enterprises some time ago. The basic steel industry in the industrial west of the Fatherland has been largely assisted in its development in recent years by reason of the raw material requisitioned from the Swedish mines, and any reduction in the deliveries from the latter would consequently be a matter of grave apprehension to its future progress when considered from the German point of view, which is beginning to turn somewhat in the direction of the more extended working of native sources of iron ore, although these are of inferior quality to the Swedish commodity. After all, what has happened in Sweden? The Government have replied, according to Count Posadowsky, that they alone cannot alter anything in the agreement between the State Railways and the—iron ore—companies, which was concluded on the basis of the limited capacity of the railway, but that they would have to enter into negotiations with the Swedish Parliament. In the circumstances it is obvious that the Swedish Government are in the hands of the Parliament, and that when the former actually desired to transport a larger tonnage of ore the latter vetoed the proposal. We scarcely see that Germany has any more reason to complain than Great Britain of the present situation of affairs, although the former country is unable to buy a larger quantity than Swedish producers are permitted to export under existing agreements. At the same time there stands in the background the Swedish idea of becoming a large maker and exporter of iron and steel at some future period. It may be, and very probably is, an insoluble problem, owing to the absence of supplies of coal and coke, and the intention to use the water-power of the country for the production of electrical energy for working the railways, so that there might be little left available for the electrical manufacture of iron and steel on a large scale. But the idea exists in influential circles, and it will in all likelihood continue to hamper the exportation of iron ore in the future.

The Grantham Railway Accident.

ON Thursday afternoon Lt.-Col. Von Donop's report on the disastrous railway accident at Grantham Station on September 19th appeared. The principal circumstances of the accident are too fresh in the mind to need recalling, but they will be found in our issues of about that time, and to those pages we may for the present, refer our readers. The accident has, in the course of the discussion on it, been confused by several side issues, but there is one and only one fact to account for. It is why the train, driven by a man who knew the road well, passed several signals at danger at high speed, and dashed through a station at which it should have stopped? To that question Lieut.-Colonel von Donop is unable to give anything approaching a definite answer, but he is able to show from an investigation of the evidence that it was not due to defects of the brake or the engine itself, and that the fault has to be sought in a human, and not in a mechanical, element. Let us briefly recount the facts which have confirmed him in this opinion. First, with regard to the engine. It was carefully examined as soon after the accident as possible, and it was found that the reversing lever was in the forward position, and the regulator and the blower valve both partly open. The regulator handle had, however, received a severe blow in the direction which would have tended to open it, and it is, therefore, unsafe to assume that it was open at the moment before the accident occurred. The handle for working the blower was broken off, but the valve itself was slightly open. It is customary to open this valve a little before turning off steam in order to prevent the fire blowing back into the cab when the draught caused by the exhaust ceases. "There is," says the report, "no other reason why this valve should have been opened, except that the driver opened it preparatory to turning off steam; and from the fact of this valve being opened, it is probable, though not certain, that steam was turned off prior to the derailment." There is thus no doubt that the engine itself had no fault which could have been responsible for the disaster. The brake is the next point that requires consideration. The driver's valve was open, but the handle had received a severe blow in the direction which would have opened it, and therefore no deduction can safely be made from this observation. The brakes themselves were, without doubt, properly coupled up and in working order; of that there seems not the remotest doubt, and there seems also, from the evidence, no doubt that immediately before the derailment the wheels of the train were skidding, thus showing that the continuous brake was acting efficiently. "There seems, therefore," says Colonel von Donop, in conclusion of this section of the inquiry, "to be no grounds to substantiate the view that the failure to stop at Grantham was due to any defect in the mechanism for turning off steam or to any failure of the vacuum brake." We now turn to the consideration of the human element. The sobriety and competence of both Fleetwood, the driver, and Talbot, the fireman, are absolutely proved. Col. von Donop dismisses the suggestion that they temporarily forgot the stop at Grantham, and though he acknowledges that the suggestion receives some support from the evidence, he cannot, in face of the numerous landmarks in the neighbourhood of the station, admit that the driver lost his way and did not realise how close he was to Grantham. It is in some sudden seizure of the driver that he obviously sees the most probable cause of the accident. It is shown by the evidence that Fleetwood had on several occasions been absent on sick leave, and it is also made quite clear that he was not on any of these occasions seen by the doctor. It is, therefore, unknown what his complaint was. Colonel von Donop remarks with some force, "It certainly appears to be an injudicious arrangement that a man, carrying out the responsible duties of engine-driver, should be absent from work without the company knowing definitely what is the matter with him, and still more injudicious that he should be permitted to resume work after an illness without a medical examination." It will, we think, be generally agreed that some kind of supervision in this respect is desirable.

The Grantham accident therefore remains a mystery, and must so remain. After examining all the evidence that he was able to collect Col. von Donop is only able to conclude—"The above are the only surmises which can be made as to why the train failed to stop at Grantham. A sudden illness of the driver appears certainly the most probable, but there is no direct evidence completely to substantiate any one of them; it is feared therefore that the primary cause of this accident must for ever remain a mystery."

DEVELOPMENT OF THE FRENCH AUTOMOBILE INDUSTRY.

No. I.

THE leading note of the annual exhibition of motor vehicles which was opened last week in the Grand Palais in Paris is that the show has more the character of a popular demonstration of automobilism than of an object-lesson in the technical advance of the motor car. This does not imply that there is any diminution in the interest of the show from the point of view of the automobile engineer, for the display of parts, accessories and specialities, is of itself sufficiently remarkable to justify a prolonged visit, while on the Esplanade des Invalides the collection of industrial vehicles must be regarded as one of the largest and most varied yet brought together. As, however, it is in the car that improvement is looked for, the exhibition of pleasure vehicles is slightly disappointing. It is true that they nearly all repay examination, and on most of them there are refinements which tend more or less towards perfection; but it must be admitted that there is little evidence of any distinct advance in general design during the past year. On the other hand, the exhibits are staged to perfection. Nothing can surpass the brilliancy of the designs of individual stands and of the illuminations both inside and outside the Grand Palais, with the blaze of light extending across the Alexandra Bridge to the temporary buildings erected on the Esplanade des Invalides for the industrial vehicles. It is difficult to see how anything better can be done in the future. It is clear that the French industry is trying to make up for an absence of novelty in mechanism by a display that will attract the general public with a view of bringing in an increasingly large circle of customers.

Although it was feared that the settling down of the motor vehicle to standard types would have the effect of diminishing the importance of the Paris Salon as an international market for motor vehicles, it must be confessed that there is not yet evidence of any withdrawal of foreign interest in these annual gatherings. It appears as if the number of visitors from England, Germany, Italy, Belgium, and other countries is quite as large as it has been in previous years, and it is characteristic that many of the foreign makers of cars are exhibiting at the Salon more largely than was the case last year, when there seemed to be a movement abroad for boycotting the Salon in the hope of diverting business to London, Berlin, and elsewhere. Quite a number of British exhibitors are showing in Paris, among whom may be mentioned the Argyll, New Enfield, and Daimler, while the Rolls-Royce and Napier cars are exhibited on other stands. Contrary to the practice adopted in previous years, the foreign cars are grouped together in the main hall, where the Italians are making an especially large display. The universal character of the industry is, moreover, seen in the participa-

tion of Spain, which, for the first time, is directly represented at this great automobile manifestation. While the show is attracting such a large number of foreign visitors it is probable that only a small proportion of them are bent on business and have come chiefly to see what the French are doing in the designing of cars. There is also a number of agents who are looking out for suitable types of cars that can be sold in their respective countries. English agents, for example, are particularly keen on discovering small and cheap cars, but of these the display is not altogether a satisfactory one, for although a larger number of firms is showing voiturettes than was the case last year, there are exceedingly few that can be expected to meet with any commercial success. Nowhere has the voiturette received more attention than in France. The problem of the cheap car has, however, been left almost exclusively to small makers who have not the facilities for turning them out under conditions to make the business a financial success, and those big firms which have from time to time brought out cheap cars appear to be making no effort to cater for this branch of the trade. They argue that so long as there is an increasing demand for the higher-priced vehicles they have no need to go in for cheap cars, upon which the profits are necessarily very small. Nevertheless, it may be taken for granted that as soon as there is evidence of the production exceeding the demand, so as to lessen makers' profits, they will take up the problem of the cheap vehicle.

The position of the French industry differs considerably from that in other countries in the sense that the productive capacity is almost unlimited. This is due to the specialising of the trade, in which there are many hundreds of firms which manufacture parts and accessories. A builder of cars starting with a small capital has therefore no necessity to lay down a costly plant, but can purchase his frames, engines, gears, axles, clutches, and, in fact, every component part, which he merely assembles. His engineering knowledge is valuable in selecting the best materials, assembling them in the most practical way, and in "tuning up" the cars before delivering them to customers. The manufacture of parts has developed into such a vast industry that the French have really no further inducement to change the design of their mechanism, which must necessarily cause an entire upheaval in the business of hundreds of makers. For this reason makers are endeavouring to perfect the standard type rather than carry out experiments with entirely new systems. They are encouraged in this policy by the firm belief that the standard type of mechanism represents the best that it is possible to attain with the internal combustion engine. They have now an engine which is sufficiently flexible in power for ordinary purposes, and the transmission gears have been brought to a degree of efficiency that could scarcely have been anticipated a few years ago. Improvement, therefore, is centred in points of detail which, while interesting, mark a stage in design beyond which further progress is necessarily slow. As a matter of fact, both in the engine and transmission gear any improvement is merely a question of refinement, and makers' attention is centred now mainly in the direction of finding a coupling between the two which will allow of the engine taking up its load without shock, and at the same time of absorbing some of the power in friction before reaching the road wheels, so as to permit of a wide range in the speed at which the car is driven. This question of clutches, as well as of other details in car construction, will be dealt with in future articles.

While we have inferred that the standard type of mechanism appears to be reaching a limit in improvement—and French makers are, as a rule, opposed to the introduction of any striking changes in design which may interfere with the processes of manufacture, unless, of course, these changes obviously give very much better results—it must yet be admitted that manufacturers are still far from being satisfied with the general convenience of the vehicle, by which we mean more especially the facility with which the car can be driven at any speed. This is the chief cause of the introduction of the six-cylinder engine, of which large numbers are being exhibited at the Salon, but the French firms, as a rule, refuse to admit that the advantages of the six-cylinder engine are of more importance than its drawbacks. The popularity of the six-cylinder engine is still in the balance, and will probably remain so while there is a prospect of something being done in the way of increasing the range of power of the petrol motor. The various means proposed for doing this will be dealt with when we describe the special features of the Salon. The six-cylinder engine, the slipping clutch, the self-starting device, and other refinements noticeable at the Paris show are the direct outcome of a new problem which has been set French manufacturers. Until recently they have been giving their attention almost entirely to the construction of an essentially touring type of car, which is at the same time fast and commodious, and in which the variation of engine power is not of very great importance when used in conjunction with the change speed gear. The demand now, however, is running almost entirely upon a type of vehicle which can be employed for town use. The problem therefore becomes somewhat complicated, since with the aid of an engine which is incapable of giving a constant torque it is required to drive a vehicle under every possible condition of traffic, slowing down and stopping and picking up almost instantaneously, without its being necessary constantly to manipulate the change-speed lever. By thus attempting to produce a type of vehicle that can be conveniently employed for town work, the French makers are giving a distinctive character to their design, which must eventually result in the building of a very flexible and comfortable type of vehicle. To this extent the French maker appears to be working on more satisfactory lines than foreign manufacturers, who appear to be still looking closely to the requirements in purely touring types of cars.

THE TRIALS OF SUCTION GAS PLANTS AT DERBY, 1906.

THE report of the trials of suction-gas producers, which were held by the Royal Agricultural Society, at Derby, in June last, was presented to the Committee on Wednesday last. It is a fairly long and a very interesting and instructive document. We shall not be able to spare space to print the whole of it, but to-day we give the tables and results of the trials, and next week we shall give Captain Sankey's remarks upon them. The description of the engines and plants appeared in THE ENGINEER of June 15th, 22nd, 29th last. Captain Sankey and Professor Dalby were the official judges.

DESCRIPTION OF THE TRIALS.

The tria's were started at 9 a.m., on Monday, June 18th, and began with the full load trials, using anthracite as a fuel. The producers were empty, and the time of starting each engine, and of getting on the full load, from the moment of laying the fire, was noted. The various plants were started at intervals, and each was run for nine hours on full load, and then stopped. The hopper and the fire doors of every producer were then sealed up. The last engine was stopped at about 7 p.m. During the night the fires were banked, and on :—

Tuesday, June 19th, at 9 a.m., the first plant started on Monday was got under way, and the time required before the engine could be started and the full load put on was noted. The other plants were successively started in the same manner, so that in each case the fires were banked for approximately fourteen hours. The full load was maintained for five hours, after which the engines were stopped, the fires drawn, and the partially consumed fuel placed in iron vessels for weighing and examination.

Friday, June 22nd.—The full load coke trial was made on this day, and the first engine was started at 9 a.m. The time required to start the engine and get on full load was noted, after which each engine was run for nine hours on full load. On stopping the engine the fire was drawn and the unburnt fuel placed in iron vessels for weighing and examination.

In all the above trials the engines and producers were entirely in the hands of the representatives of the exhibitors, and so long as the load was maintained within a 5 per cent. limit during the time specified they were at liberty to make any adjustments they desired, which were, however, noted. In some cases not a handle was touched during each day's run.

Saturday, June 23rd.—A "novice" trial was made with three of the engines, namely, the National, the Campbell "hit-and-miss," and the 15 horse-power Crossley. The producers were got ready by each competitor to supply gas, but the engine was twice started and the load put on by the observer who had had charge of the log sheet for that particular engine. Not the slightest difficulty was experienced in thus starting any of these engines. In each case the fly-wheel was turned round by Mr. Marshall, one of the assistant engineers.

The valves were withdrawn from most of the engines, and the pistons from some of them. The generator of the producer exhibited by the National Gas Engine Company was dismantled. The firebrick lining of all the producers was examined to estimate the amount of clinker adhering.

Investigations and inquiries as to the design of the plant were made during the whole of the trials, as well as observations as to the regularity and the smoothness of running. Each point was considered separately, and every plant was examined seriatim. In this way the determination of the relative value of each plant in respect of each particular point was better ensured.

MEASUREMENTS AND OBSERVATIONS.

The following is a detailed description of the measurements and the observations that were taken.

TABLE III.—*Particulars of Fuel consumed.*

Name of plant	Full load. Anthracite				Half load. Anthracite				Full load. Coke		
	Coal issued	Coal returned	Hot coal from producer	Per cent. deduction	Coal issued	Coal returned	Hot coal from producer	Per cent. deduction	Coke used	Hot coke from producer	Per cent. deduction
	Lb.	Lb.	Lb.		Lb.	Lb.	Lb		Lb.	Lb.	
National	496½	53	156½	10 [1]	290	69	133½	5	280½	73½	15
Railway and General	574	83½	85	12	245	63½	82½	12	290	41	15
Davey-Paxman	491	121	83½	11	202	66½	45	15	286	96½	10
Dowson	440½	28½	111½	10	249	55	112	9	278½	61½	25
Campbell	354	35	42½	30 [4]	145½	32½	39½	35	242½	56½	30
Campbell (Throttle)	406½	27½	61½	31	161½	21½	50	35	269½	70	20
Dudbridge	429½	20	126½	30	265	60	100½	25	239½	71½	30
Mersey	450½	20½	144½	15	316	68½	157	15	283½	88½	30
Hindley [3]	492½	105½	72½	34	320½	Fuel not	returned	—	—	—	—
Kynoch	427½	0	138½	6	296½	85	142	7	269	55½	15
Newton [3]	578 5	10	Not weighed		309½	97	Not weighed		—	—	—
Fielding	445	26	116	30	171½	24	61½	33	276½	40½	60
Crossley [4]	362½	—	—	—	—	—	—	—	—	—	—
Crossley	449½	10	219½	13 [1]	311½	140	102½	8	251	95½	15

[1] Verified by calorimetric determinations made at the Central Technical College, Exhibition-road, S.W. [2] Withdrawn during half load trial. [3] Withdrawn before coke trial. [4] Withdrawn.

TABLE IV.—*Particulars of Full Load Trial with Anthracite.*

Name of plant	Total hours running on full load. Banked 14 hours	Net coal used	Coal per hour of running time	Total water used	Water per hour	Average load on brake	Average revs. per min.	Brake constant	Average B.H.P.	Coal per B.H.P. per hour	Water per B.H.P. per hour	Per cent. of declared full load	Per cent. of Catalogue full load
		Lb.	Lb.	Gallons	Gallons					Lb.	Gallons		
National	14·02	303	21·6	329	23·5	192·5	191·8	·000558	20·6	1·04	1·14	103	103
Railway and General	14·00	416	29·7	1,012	72·3	220·0	170·5	·000533	20·2	1·48	3·61	100	100
Davey-Paxman	14·00	295	21·1	248	17·7	149·4	226·1	·000464	16·4	1·28	1·08	106	106
Dowson	14·08	312	22·2	264	20·0	189·4	192·4	·000559	20·4	1·09	0·98	102	102
Campbell	12·70	289	21·1	324	23·6	245·5	201·8	·000390	19·3	1·09	1·22	107	107
Campbell (Throttle)	14·00	336	24·0	393	29·6	280·6	188·8	·000389	21·4	1·12	1·38	107	107
Dudbridge	14·00	321	22·9	602	43·0	207·2	193·4	·000389	15·5	1·47	2·76	77·5	77·5
Mersey	13·93	307	22·0	668	48·3	280·0	203·5	·000343	19·5	1·13	2·47	97·5	97·5
Hindley	Trial incomplete												
Kynoch	14·00	297	21·2	180	13·4	115·2	240·0	·000668	18·4	1·15	0·73	108	108
Newton	14·05	—	—	709	50·4	193·0	192·5	·000487	18·1	—	2·80	—	90
Fielding	14·00	338	24·1	516	36·8	174·4	318·5	·000484	18·4	1·31	2·00	102	92
Crossley	Withdrawn												
Crossley	14·00	247	17·6	517	37·6	195·3	178·7	·000439	15·3	1·15	2·45	102	102

Fuel returned from producer not weighed

This completed the full load anthracite trials, which consisted of nine hours full load, fourteen hours banked fires, and five hours full load.

Wednesday, June 20th.—The half-load anthracite trial was carried out this day; the starting of the plants from laying the fire was a repetition of the trials carried out on Monday. Each engine ran for nine hours on half-load when the engine was stopped, the fire drawn, and the fuel placed in iron vessels for weighing and examination as before.

Thursday, June 21st.—The variable load trial was made on this day; the first plant was started at 9 a.m. and the others were started in succession at short intervals. Each engine was run for two hours with no load from the time of starting. Then full load was quickly put on and maintained for one hour, when the load was taken off, and the engine was run for one hour with no load. Then one-third load was suddenly put on and maintained for one hour, when the load was increased to half-load, which was kept on for one hour, when full load was put on and maintained for one hour. The fuel used was anthracite, but no measurement of the amount used was made.

Observers.—The log sheet for each plant was kept on a specia form, and there was one observer for each two plants during the first days of the trial. Later, when some of the plants had been withdrawn from competition, the more important plants had an observer each.

Fuel.—The coal used was Western Valleys anthracite, and was supplied by the Derby Coal Company, Limited. It was of the size known as "beans." This coal was chosen because it is well known, and easily obtained of an uniform quality. Expert opinion was taken on this point. It was stored in a covered shed which was kept locked, and was under the charge of a watchman at night.

It contained 3·22 per cent. of moisture, and 6·44 per cent of ash, the effective calorific value, determined by combustion by oxygen under pressure, being 7·475 calories per gramme. The hydrogen only amounted to 2·7 per cent.

Adjoining the coal store a weighing-room was provided and fitted with three 5-cwt. platform weighing machines, lent by Messrs. W. and T. Avery, Limited, of Birmingham.

At the commencement of each trial each competitor was supplied with the quantity of coal asked for, and this was delivered in bags

supplied by each competitor, the tare of which was carefully taken.

At the finish of the trials all coal not in the producers was returned and weighed in the bags, and returned to the store, the tare of the bags being checked before being returned to the owners. All fuel in the producers was raked out immediately on the conclusion of each trial, and placed in an iron pan with cover, and taken to the yard behind the trial shed, where it was weighed, without having been quenched with water, and immediately emptied near the peg marked with the competitor's name, to be examined by the judges when cold.

The coke was supplied by the Derby Gas Company, and was selected as free from tar as possible, and picked to a uniform size of 3in.

The unburnt fuel spread out near each competitor's peg, as already mentioned, was carefully turned over and examined. The clinker was separated and weighed, and a note was made of its nature, whether friable or vitreous. At the same time, an estimate was made of the calorific value of the fuel taken out of the producers, as compared with the raw fuel, and this estimate was subsequently checked by calorimetric determination made with three of these partly burnt fuels at the Central Technical College. The weight of the equivalent raw fuel was deduced, and the amount was deducted from the gross fuel issued; thus the net fuel used during the test was obtained with sufficient accuracy for the purposes of these trials.

Measurement of water used.—The water used by the scrubber and the vaporiser was measured by means of water meters lent by Messrs. Beck and Co., Limited, which were of the positive type—Schonheyder's patent—and a testing cock was placed on the delivery side. All the meters were carefully calibrated and found to be correct previous to the trials, and certain of them were again calibrated after the trials and were still correct.

By far the greater proportion of the water used by a producer is required for the scrubber. In fact, the water required by the vaporiser is comparatively so small in amount that the water passing through the meter can be regarded as the water required by the scrubber.

If the scrubber is working properly and with a sufficiency of water, the gas ought to be cold, and it was, in fact, observed to be in all cases only a few degrees above the air temperature.

As already stated, the amount of water required for producing steam in the vaporiser is small, and from the cost of water point of view is unimportant. A few measurements of the vaporising water were made during the coke trials by noting the time required to fill a 500 cubic centimetre glass measure, and the result is given in Table X. The importance of accurately regulating the vaporising water supply has already been referred to, and, as the pressure in the water main cannot, as a rule, be depended upon, it is prudent to fit a small tank with a ball cock so as to maintain a constant head. Some of the competitors had fitted such tanks; others had not.

Lubricating oil.—No determination could be made of the actual amount used during the trials, but it appeared to be quite moderate. From other sources the quantity of oil required for lubrication may be taken as about half a gallon per 20 brake horse-power per week. If the main bearings are fitted with ring lubricators, the quantity will be less.

Measurement of brake horse-power.—A rope brake of simple design, similar to those used in the trials of oil engines at the Cambridge and Cardiff meetings of the Society, was used.

Indicator diagrams and the measurement of the indicated horse-power.—Indicator diagrams were taken at intervals and were studied as regards the initial and compression pressures, &c., but as no great reliance can be placed on indicator diagrams taken from gas engines as regards measurement of power * the indicated horse-power was not determined, and hence the brake efficiency, that is, the ratio of the brake horse-power to the indicated horse-power, was not obtained. Even if reliable diagrams could have been obtained the staff of observers was insufficient to take the necessary number of diagrams from each engine. Moreover, the indicator gear fitted to some of the engines consisted merely of a pin fixed to the end of the crank shaft and rotating with it. As is well known such an arrangement cannot give a true indicator diagram, and at any rate is quite useless as regards obtaining the indicated horse-power. Many of the gears were insufficiently stiff, and errors were imported thereby. A certain number of light spring cards were also taken and gave useful information with regard to the running of the engines. A number of diagrams were taken with the Mathot indicator, and some extremely interesting results were obtained which will subsequently be referred to.

Revolutions.—The total revolutions for each test were obtained by means of revolution counters. Readings were taken of these counters at intervals, from which the revolutions per minute could be deduced. These observations are, however, difficult to take, and, in many cases, the result was unsatisfactory; there were apparent fluctuations of speed which certainly did not exist. These counters, however, gave the correct mean speed were taken over a long interval of time.

Explosions per minute.—The total number of explosions during each test was recorded by a counter. Several of these counters gave much trouble and were quite unreliable. Readings at intervals were also taken to obtain the explosions per minute to see if any variation took place during the progress of the trial; these readings, however, are subject to the same errors as noted above in connection with revolution counters.

Messrs. Heyward and Marshall took check readings of both revolutions and explosions per minute.

Producer gas.—No attempt was made to obtain either the composition or the temperature of the producer gases. A largely increased staff would have been needed for making such observations.

Time required to start.—The time required to start the plant is of some importance, and it is necessary to distinguish between starting with an empty producer and with one in which the fire has been banked. The former was tried on Monday, June 18th, and again on the Wednesday, and the latter on the Tuesday. As regards the producer the time of starting should undoubtedly be reckoned as the time required for producing good gas from the moment of lighting up, or from starting blowing in the case of banked fires. The gas could have been tested by lighting it and observing the colour of the flame; but the most reliable test is whether the gas is capable of running the engine with a load; therefore the time required before the load could be put on was the fairest guide. The skill and temperament of the attendant in judging of the quality of the gas is, however, an important factor, and thus a plant which can be quickly started may lose time owing to the attendant thinking that the gas is good before it is, leading to a false start. It was, in fact, noted that some of the attendants in their anxiety to make a quick start did so before the gas was good, with the consequence of making a false start and delaying matters.

On the other hand, the attendant may not have started the engine as soon as he might have done. In both cases the starting time is longer than necessary. Too much stress should not, therefore, be laid on these competitive starting times. Moreover, unfortunately, on Monday some of the kindling wood was damp, and this caused delay in getting some of the fires lighted. A few of the competitors had taken the wise precaution to dry their wood; but in the case of the National plant the wood could not be lighted without the use of a little paraffin oil, and in both Messrs Crossley's plants, after vain attempts, the fire had to be drawn and a fresh start made with a new supply of kindling wood. On Monday and Tuesday some of the competitors, in order to reduce the time of starting, opened vent pipes in a manner which should not occur in actual use, owing to the possibility of poisoning by carbonic oxide. On Wednesday this was not permitted, and in some cases a marked increase in the time required to start was observed. At the coke trial on Thursday there was no competition as regards the time of starting, and a considerable increase was noticeable, due no doubt in some measure to the greater difficulty in getting coke to burn, and also because, just at first, there is a difficulty in obtaining a sufficiently inflammable gas—hydrogen.[1] These times may be regarded as those likely to obtain in actual practical use with coke—see Table VIII.

Smoothness of running.—An estimate was made of the comparative smoothness of running by carefully listening to the running of each engine, and by feeling the bearings to notice if there was any undue knock. The smoothness of running of the valves was also noted. The bearings were examined on several occasions after the engines were stopped. They were invariably quite cold. An exception, however, must be made in the case of the Hindley engine, which was running in a closed crank chamber, so that the bearings, and, in fact, all the working parts, were heated by conduction from the cylinders; the bearings were, however, not unduly warm. The bearings of the Newton engine, which was also enclosed, were not examined.

Circulating water.—As regards the circulating water for the cylinder jackets three tanks were provided for each engine, but no attempt was made to regulate the temperature of the circulating water, as it was considered that this was a matter to be adjusted by each competitor to suit what he considered to be the best temperature.

Attendance required.—A note was made of the number of attendants actually employed at the trials. But this is not necessarily the number that would actually be required when at work on the customer's premises.

Noise.—Notes were made as to the noise produced by the various engines in respect of the valve gear and the magneto detent. The exhaust noise was considerable, and in no case was the silencer really satisfactory. The combined effect of fourteen exhausts was distinctly annoying. Probably that of a single engine might not have been very noticeable.

Ashes produced.—In some cases the ashes were more or less separate from the coal or coke raked out of the producer at the end of the run and could be weighed. In other cases they were so mixed up with the fuel as to render any separation practically hopeless. The matter was not one of great moment, however, as the amount of ashes depends more on the fuel than on the producer. In this connection a great difference was noted as regards the appearance of the fuel that came out of the various producers at the end of a run; in some cases it appeared as if it had never been used, in others it looked more like cinders full of ashes. This may, however, be in great part due to the manner in which the various attendants fed in the fuel towards the end of the run—that is, the final condition of the fire and fuel may not have been that obtaining during the whole of the trial.

Clinker.—The quantity and nature of the clinker produced was specially observed, because the satisfactory continuous running of suction gas plants depends not only on the amount of the clinker, but whether it adheres to the firebrick lining or not, and whether it comes away easily when raking out the ashes; that is, whether the clinker is friable or vitreous. As regards the design of the producer, the points noticed in this connection were: the manner of supplying water to the vaporiser—since the clinker depends on the steam—and the shape of the furnace at the bottom and of the grate. An estimate of the amount of clinker adhering to the firebrick lining was also made. I again quote from Professor Dalby's paper:—

"Nothing disturbs the regularity of working so much as the clinkering of the fuel. Clinker in the fire prevents the supply of air from spreading uniformly through the incandescent fuel, and thus causes irregularity of the fire, which in its turn causes irregularities in the quality of the gas. The quantity of air passing through the fire gets gradually less as the obstruction caused by the clinkers gradually increases. If clinkering cannot be altogether prevented, that which is formed should be of a friable nature, so that it can easily be removed without damage to the furnace lining.

"The formation of clinker can be minimised by keeping the temperature of the fire relatively low, and this is accomplished by the steam which is introduced in the air supply."[2]

Clinkering whilst running.—Better provision was made for this operation in some of the producers than in others as regards the arrangements of the doors, and such producers are obviously better suited for continuous running and for working with inferior fuels. If the ash door is opened for clinkering whilst running, an undue amount of dry air enters the furnace—that is to say, there is insufficient steam. In the Mersey producer a water tap was fitted which could be utilised for temporarily increasing the amount of steam when clinkering. A can of water emptied on the grate practically answers the same purpose.

Space occupied.—As arranged for the trials some of the plants occupied a great deal more room than others. But this was due to the different amount of space available as taken up by the various exhibitors. Any of the plants could easily be erected on a floor space 17ft. by 14ft. From the competitive point of view there was no sensible difference in any of the plants exhibited in this respect.

Chances of explosion.—A careful examination showed that, except from carelessness on the part of the attendant, the chances of a harmful explosion are practically nil. To cause an explosion it would be necessary for the attendant to open the feeding door to the hopper at the same time as the valve communicating from the hopper to the furnace. In the case of the Mersey producer, the hopper was so arranged that such a through communication is impossible. A similar provision might be adopted with advantage in other cases. A slight explosion occurred on starting the National engine on Monday, June 18th, when opening the fire-door, and in another case there was a slight explosion and flame when "blowing up" the producer. As already pointed out, the water seal of the scrubber prevents gas getting back and acts as a safety valve.

Chances of poisoning.—Since the gas produced contains a large amount of carbonic oxide, which is of a very poisonous nature, and being inodorous may easily escape detection, the chances of poisoning were carefully considered. When the engine is working, the pressure in the producer is below that of the atmosphere, and therefore any leakage would be into the producer. It is, therefore, when the producer is being started, or opened up after running, that there is any real danger of poisoning; but an

TABLE V.—*Particulars of Half Load Trial with Anthracite.*

Name of plant	Total hours running on full load	Net coal used	Coal per hour	Total water used	Water per hour	Average load on brake	Average revs. per min.	Brake constant	Average B.H.P.	Coal per B.H.P. per hour	Water per B.H.P. per hour	Per cent. of declared full load	Consumption of coal adjusted to 50 per cent. of declared full load
		Lb.	Lb.	Gallons	Gallons					Lb.	Lb.		Lb.
National	6·00	94	15·7	31	5·17	93·7	193·6	·000558	10·1	1·55	0·52	50·5	1·55
Railway and General	6·00	109	18·2	112	18·67	111·5	173·2	·000533	10·3	1·77	1·81	51·5	1·78
Davey-Paxman	6·00	97	16·2	52	8·67	72·8	231·6	·000484	6·2	1·98	1·06	53·0	2·06
Dowson	6·00	92	15·3	41	6·83	95·5	194·9	·000559	10·3	1·49	0·66	51·5	1·51
Campbell	6·00	89	14·8	88	14·67	134·3	202·0	·000390	10·6	1·38	1·39	59·0	1·50
Campbell (Throttle)	6·00	100	16·7	121	20·17	153·5	195·3	·000389	11·7	1·43	1·72	58·6	1·54
Dudbridge	6·00	110	18·3	120	20·00	121·4	197·2	·000389	9·3	1·97	2·15	46·5	1·99
Mersey	6·00	114	19·0	200	33·33	138·0	206·3	·000343	9·8	1·95	3·42	49·0	1·91
Hindley	—	—	—	—	—	—	—	—	—	—	—	—	—
Kynoch	6·00	99	16·6	21	3·50	60·4	240·6	·000668	9·7	1·71	3·61	57·0	1·88
Newton	5·00	—	—	124	21·8	101·0	196·3	·000487	9·6	—	2·58	48·0	—
Fielding	6·00	106	17·7	133	21·17	85·2	222·0	·000484	9·2	1·92	2·41	51·0	1·95
Crossley	—	—	—	—	—	—	—	—	—	—	—	—	—
Crossley	6·02	77	12·8	45	7·47	105·2	181·3	·000439	8·4	1·52	0·89	56·0	1·62

TABLE VI.—*Particulars of Full Load Trial with Coke.*

Name of plant.	Total hours run on full load	Net coke used	Coke per hour	Total water used	Water per hour	Average load on brake	Average revs. per min.	Brake constant	Average B.H.P.	Coke per B.H.P. per hour	Water per B.H.P. per hour.	Per cent. of declared full load.	Per cent of Catalogue full load
		Lb.	Lb.	Gallons	Gallons	Lb.				Lb.	Gallons		
National	9.00	224	24·8	258	28·7	191·9	190·8	·000558	20·5	1·21	1·40	102	102
Railway and General	9.00	255	28·3	710	78·9	207·5	183·1	·000533	20·2	1·40	3·90	101	101
Davey-Paxman	9.00	199	22·1	191	21·2	120·4	231·4	·000484	13·4	1·64	1·58	86·5	86·5
Dowson	9.00	232	25·8	320	35·6	193·3	188·8	·000559	20·4	1·26	1·75	102	102
Campbell	9.00	203	22·6	440	48·9	203·8	201·3	·000390	17·0	1·33	2·88	100	94·5
Campbell (Throttle)	9.00	214	23·7	330	36·7	231·3	190·5	·000389	17·1	1·39	2·12	95	85·5
Dudbridge	7.33	189	25·7	517	70·5	206·7	194·1	·000389	15·6	1·65	4·52	78	78
Mersey	9.00	213	23·7	875	97·2	240·0	205·5	·000343	16·9	1·40	5·70	84·5	84·5
Hindley	—	—	—	—		—	—	—	—	—	—	—	—
Kynoch	9.00	222	24·7	284	31·6	112·3	240·4	·000668	18·0	1·37	1·75	106	103
Newton	—	—	—	—	—	—	—	—	—	—	—	—	—
Fielding	9.00	250	27·8	440	48·9	176·4	221·0	·000484	18·8	1·48	2·06	104·5	94
Crossley	—	—	—	—	—	—	—	—	—	—	—	—	—
Crossley	9.00	170	18·9	720	80	174·2	181·6	·000439	13·9	1·36	5·76	107	93

* This conclusion was come to by the Committee of the Institution of Civil Engineers on Internal Combustion Engines (see pages 247 and 268, "Minutes of Proceedings Inst. C.E.," vol. clxiii.).

[1] With anthracite there is a small proportion of volatile hydrocarbons which are distilled from the fresh coal, and give the inflammable gas required for starting.

[2] "Suction Gas Plants," by Professor W. E. Dalby, M.A., B.Sc., British Association, August, 1906.

TABLE VII.—*Variable Load Trial (Anthracite).*

Name of plant	No load—2 hours. Notes	Revs. per min.	Explosions per min.	Full load—1 hour. Notes	Revs. per min.	Explosions per min.	No load—1 hour Notes	Revs. per min.	Explosions per min.	One-third load—1 hour. Notes	Revs. per min.	Explosions per min.	Half load—1 hour. Notes	Revs. per min.	Explosions per min.	Full load—1 hour. Notes	Revs. per min.	Explosions per min.
National	Satisfactory	196	18	Took 3½ min. to get on full load. Speed maintained	188	75	Satisfactory	196	18	Speed maintained. Satisfactory	195	35	Speed maintained. Satisfactory	192	58	Speed maintained. Satisfactory	190	80
Railway and General	Satisfactory	175	19	Engine stopped and fan had to be used. Took 15 min. to get on full load	173	67	Somewhat unsteady	174	17	Engine stopped, fan used. Took 6 min. to get on ½ load	163	29	Speed maintained. Satisfactory	162	39	Speed maintained. Satisfactory	174	65
Davey-Paxman	Satisfactory	232	53	Engine slowed down. Took 5½ min. to get on full load	232	110	Satisfactory	241	55	Speed maintained. Satisfactory	221	75	Speed maintained. Satisfactory	231	95	Speed maintained. Satisfactory	221	113
Dowson	Satisfactory. Adjustments made to gas value	197	23	Engine stopped and fan had to be used. Took 9 min. to get on full load	191	83	Satisfactory. Air valve regulated	190	32	Engine slowed. Satisfactory	193	36	Speed maintained. Satisfactory	194	50	Speed maintained. Satisfactory	191	84
Campbell	Satisfactory	207	23	Engine slowed down. Took 1½ min. to get on full load	201	76	Satisfactory	208	22	Speed maintained. Satisfactory	207	30	Speed maintained. Satisfactory	204	48	Full load in 1½ min. Speed maintained. Satisfactory	201	77
Campbell (Throttle)	Satisfactory	198	90	Speed maintained. Took 2 min. to get on full load	192	96	Satisfactory	196	98	Speed maintained. Satisfactory	192	96	Speed maintained. Satisfactory	196	98	Speed maintained. Satisfactory	196	98
Dudbridge	Satisfactory	201	19	Engine slowed down. Took 3 min. to get on full load	193	77	Satisfactory	199	21	Took ½ min. to get on load. Satisfactory	203	32	Slowed down slightly. Satisfactory	198	42	Speed maintained. Took 1 min. to get on load. Satisfactory	193	82
Mersey	Satisfactory	209	27	Engine stopped for 2 min. Took 15 min. to gradually get on full load	203	91	Satisfactory	209	31	Speed maintained. Satisfactory	208	39	Speed maintained. Satisfactory	207	58	Speed maintained. Took 1½ min. to get on load. Satisfactory	204	96
Hindley	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—
Kynoch	Engine slowed down occasionally	240	41	Engine stopped for 12½ min. Fan used. Took 8 min. after restarting to get full load on	241	103	Satisfactory	242	43	Slowed down slighfly Satisfactory	241	65	Speed maintained. Satisfactory	241	70	Speed maintained. Satisfactory	240	99
Newton	Engine stopped owing to ignition. Otherwise satisfactory	195	88	Engine slowed down slightly. Took ½ min. to get on full load	194	84	Satisfactory, except stop due to ignition	196	30	Speed maintained. Fairly satisfactory	196	55	Speed maintained. Satisfactory	196	57	Speed maintained. Satisfactory	191	87
Fielding	Satisfactory	225	24	Engine slowed down. Took 3½ min. to get on full load	215	84	Satisfactory	225	20	Speed maintained. Satisfactory	223	37	Speed maintained. Satisfactory	220	40	Speed maintained. Slight adjustment of air throttle. Satisfactory	221	86
Crossley	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—
Crossley	Satisfactory	186	21	Engine slowed down. Took 4 min. to get on ½ full load. Took 10 min. to get on full load	176	77	Satisfactory	186	22	Speed maintained. Satisfactory	182	44	Speed maintained. Satisfactory	180	50	Speed fell slightly. Satisfactory	176	80

TABLE VIII.—*Time (in minutes) required to start the Engine and get on the Load specified.*

Name of plant	Monday, June 18 Producer empty, fire laid. *Anthracite*		Tuesday, June 19 Fire banked. *Anthracite*		Wednesday, June 20 Producer empty, fire laid. *Anthracite*		Thursday,[1] June 21. Producer empty, fire laid. *Anthracite*	Friday, June 22. Producer empty, fire laid. *Coke*	
National	39 (1 pint petrol)	45	10	20	15	16	Not taken	15	27
Railway and General	18	33	13	15	19	21	Not taken	22	34
Davey-Paxman	12½	17	15	19	14	15½	Not taken	36	37½
Dowson	11	16	12	18	11½	16	Not taken	13½	20
Campbell	11	14	6	7	8	9	23	19	21
Campbell (Throttle)	18	32	9	11	10	12	Not taken	20	23
Dudbridge	24 first start; 38 final start	70	9	12	11	25	40	60	127
Mersey	22	26	11	20	21	23	33	25	42
Hindley	54	62	8	14	—	—	—	—	—
Kynoch	14½	24½	5	9	8½	12	27	36	54
Newton	11	12	10[2]	11	8	9	30½	—	—
Fielding	10	16½	33	36½	6	7½	30	38	39
Crossley	—	—	—	—	—	—	—	—	—
Crossley	22 (1 pint petrol)	24	—	20	16½	18½	30	29	31

[1] On this day there was no competition as regards starting times, and therefore only a few were noted. [2] Fire had to be re-lit.

TABLE IX.—*Weight and Appearance of Clinker and Examination of Furnaces.*

Name of producer	Tuesday, June 19, after full load. Anthracite	Lb.	Examination of furnaces after variable load trial	Friday, June 22, after full load. Coke	Lb.
National	Friable, middling-sized lumps	3·5	Figure of merit 9	Friable	0·6
Railway and General	Friable, large lumps	7·3	8	Friable	2·0
Davey-Paxman	Friable, large lumps	2·5	6	Hard vitreous	4·5
Dowson	Friable, small lumps	4·9	8	Very friable	2·0
Campbell	Friable, medium-sized lumps	2·7	6	Very friable	0·9
Campbell (Thr.)	Friable, medium-sized lumps	2·5	6	Friable	1·3
Dudbridge	Vitreous, small lumps	2·2	—	Hard vitreous	2·0
Mersey	Vitreous, very small lumps	2·2	3	Hard vitreous	2·3
Hindley	Fairly friable, middling-sized lumps	—	—	—	—
Kynoch	Semi-vitreous, large lumps	3·5	4	Hard	1·0
Newton	Not observed[1]	—	—	—	—
Fielding	—	3·2	3	Hard	6·0
Crossley	Fire not drawn	—	—	—	—
Crossley	Friable, middling-sized lumps	1	10	Friable	0·2

[1] The fuel drawn from producer was not weighed nor examined, because through a misunderstanding it was dumped into the false bottom, which contained a previous dumping that had not been cleared away.

TABLE X.

Rate of Water used in Vaporisers.—Full Load Coke Trial.

Name of producer	Observation. 500 cub. centims. in: min.	sec.	Rate in gallons: Per hour for plant	Per B.H.P. per hour
National	3	16	2·0	0·4
Kynoch	1	11	5·6	0·32
Fielding	4	32	1·5	0·08
Crossley	0	58	6·8	0·5

TABLE XI.

—Time required to disconnect big end of Connecting Rod and withdraw Piston from the Cylinder.

Name of engine	Time: min.	sec.
National	2	20
Campbell	2	25
Crossley	1	15

[1] Lubricating spring cover had been previously taken off; add 20 sec.

accident could only happen through gross carelessness. When the producer is being started, there is a pressure in it due to the fan; and to reduce the effort of blowing, and get rid of the air in the pipes, &c., a large vent pipe is opened by means of a valve. The outlet of this pipe should be carried outside the building, where the discharge of gas can do no harm. A small cock has to be opened to test the gas at starting, and the arrangement of this cock was better in some of the plants than in others.

Fire risk.—There did not appear to be any serious fire risk with any of these suction producers; no more, in fact, than there would be with a slow-combustion stove.

General reliability.—The duration of the trials was too short to admit of the trials themselves discriminating between a great many of the plants in this respect. The matter had therefore to be decided as a matter of judgment based on the design of the various plants. There was no difficulty as regards the engines themselves, for the reliability of the usual design is undoubtedly as great as that of any ordinary piece of mechanism; and with due care, specially as regards the cleaning of the valves, it is certainly on a par with that of the steam engine of the same size. Attention was paid to the arrangement of the exhaust valve springs and to the air and gas valve springs. As already pointed out, the springs used in the magneto gear are of necessity somewhat delicate, and the provisions made in this respect in the case of some of the engines were far better than in others. The producers are more likely to give trouble than the engines, and the arrangements for regulating the air and the water supply were specially considered, as well as those for minimising clinkering and its bad effects.

In examining Tables IV., V., and VI., it will be observed that, notwithstanding the difficulties in making consumption tests with such plants owing to the large stopping and starting errors, the consumption of many of the engines has come out almost the same. Moreover, those engines which had a comparatively low ratio of compression gave the highest consumption, as might have been expected *à priori*, but, judging from these trials, beyond a certain ratio of compression no advantage is gained as regards consumption, as appears by comparing in Table IV., the coal consumption of the National, the Campbell "hit-and-miss," and Crossley plants; the ratio of compression in the Crossley was considerably higher than in the two former engines. In Table IV. it will be noticed that most of the engines worked slightly above the "declared" and the "catalogue" full load, and only in one case was the load seriously less. The amount of water required per B.H.P. hour varied enormously; it would appear that in many cases it was not regulated with the care that might have been expected.

The first point to observe in Table V. is that in several cases the engines did not work exactly at 50 per cent. of the "declared" full load—see last column but one. An adjustment has, therefore, been made by means of the Willans law—see last column—in order to obtain the consumption of coal at exactly 50 per cent. of the "declared" full load. On comparing Tables IV. and V., it will be noticed that the plants are practically in the same order of merit. Again, the water per brake horse-power hour varies very considerably.

In Table VI., which gives the particulars of the full load trial with coke, it will be noticed that there is considerable uniformity in the consumption figures, and that the order of merit is nearly the same as in the anthracite trials. The most noticeable point, however, is that only four of the engines worked above the "catalogue" full load, and that many of them worked at a considerably lower power. Even in the case of the "declared" full load four of the engines were unable to reach the power anticipated—see last column but one. It is thus clear that coke is generally found to be a more difficult fuel to deal with in suction producers than anthracite.

As in the previous trials there is a very great difference in the amount of water used per brake horse-power hour, and on comparing with Table IV., the amount is generally greater than in the case of anthracite.

From these trials it can be deduced that the following fuel and water consumptions may be expected with a good suction producer plant when working continuously at the loads specified and under the best conditions:—

Anthracite.

Full load.—1·1 lb. per brake horse-power hour, including fuel needed for starting and for banking during the night.

Half load.—1·6 lb. per brake horse-power hour, including coal for starting.

Water.—1 gallon per brake horse-power hour at full load and ¾ gallon at half load.

Coke.

Full load.—1·3 lb. per brake horse-power hour, including fuel needed for starting.

Water.—1½ gallons per brake horse-power hour at full load.

Variation of load trial.—No attempt was made in the variation of load trial carried out on Thursday, June 21st, to measure the consumption of fuel; the result would only have been misleading. These trials were intended to ascertain the rapidity with which the producers would respond to changes of load. The most severe of these changes was the first one made, namely, when after running for two hours with no load, the full load was suddenly put on. Some of the engines stopped, and the fan had to be brought into requisition—see Regulation 9. Even in the case of the most satisfactory plants the load had to be eased for a few seconds.

This change of loading was a severe ordeal, and was intended as a crucial test to discriminate between the competitors. The other changes of load were such as would occur in practice, and, with few exceptions, the producers responded with sufficient rapidity, and no sensible drop of speed occurred.

A summary of these variations of load trials is given in Table VII., which has been compiled from the log sheets, and is sufficiently detailed not to require much further explanation. The first change to full load after running for two hours on no load was the most severe, and no less than four of the engines stopped and the fan had to be used to start them again—see Regulation 9. All the other engines slowed down somewhat on the application of the full load, and it could only be applied gradually as noted in the table. The other changes of load were satisfactorily dealt with by the majority of the plants. It will also be noticed that the variation in the speed between full load and no load was in most cases in the neighbourhood of 5 per cent., and in some cases much less—see, for instance, the Mersey and the Newton plants.

In Table VIII. are given the times required to start the engine and get on the specified load, as abstracted from the log sheets. These times were taken from the time of laying the fire when starting with an empty producer, which was the case on all the days except Tuesday; when the fires were banked over night, the time was reckoned from the moment of commencing to blow with the fan. It will be observed that very great differences exist between the times taken by the various plants, but how far these differences are due to the suction plants themselves or to the skill of the attendant is difficult to say. In some cases, even fortuitous circumstances have a very great effect, as, for instance, in the case of the Fielding plant on Tuesday, in which the long time required was subsequently shown to be due to a piece of gauze, placed over the mouth of the trial pipe, having become coated with tar; on Wednesday, this plant actually took less time to start than any other. The difficulty experienced with wet kindling wood on Monday has already been referred to. A broad view of Table VIII. shows that a suction gas plant can be started and the full load put on in about twenty-five minutes from the time of laying the fire, and in twenty minutes from starting the fan if the fire is banked.

Table IX. gives particulars of the weight and the appearance of the clinker obtained when drawing the fires on Tuesday and Friday. It will be noticed that there is considerable difference in the weight of clinker produced, but that in most cases it was of a friable nature. In some cases, however, it is vitreous, which is a distinct disadvantage, owing to the greater liability to adhere to the fire-brick lining. The figure of merit given under the heading "Examination of Furnaces after Variable Load Trial" was a matter of estimate, 10 meaning that practically no clinker could be seen adhering to the fire-brick lining.

Dimensions, &c.—The ruling and the important dimensions of the producers and engines are given in Tables I. and XII., and from them certain deductions have been made and are entered in Table XII. These dimensions are compared with the full load B.H.P. both with anthracite and coke. The volume swept by the piston per minute during the suction strokes—no "misses"—is also given, and this is compared with the grate area and the cross section of the furnace. The volume swept by the piston per minute during the forward strokes is also compared with the brake horse-power [see Regulation 11 (7)]. The comparison is also made with the brake horse-power that would be obtained if there were no "misses." These comparisons are interesting to study; but this report is not the place to make a close criticism of such results. It will be seen, however, that with some exceptions there is no great disparity between the various plants.

Dismantling trials.—These trials were carried out as already mentioned with a few of the engines on Saturday as regards the connecting-rod and the piston, and with almost all the engines as regards the valves. The time required to withdraw the piston is given in Table XI.

TABLE XII.—*Various Comparisons.*

Name of plant	Grate area	Cross-section of furnace	Volume of furnace	Volume swept by piston during suction stroke at Catalogue revs.	Ratio of volume swept by piston to		B.H.P. obtained per sq. ft. of grate area		B.H.P. obtained per cub. ft. of furnace volume		B.H.P. obtained per cub. ft. swept by piston during forward strokes		Percentage "hits"		B.H.P. that would be obtained per cub. ft. swept if there were no "misses"	
					Grate area	Cross-section of furnace	Full load anthracite	Full load coke	Full load anthracite	Full load coke	Full load anthracite	Full load coke	Full load anthracite	Full load coke	Full load anthracite	Full load coke
	sq. ft.	sq. ft.	cub. ft.	cub. ft. per min.												
National	0·72	1·31	2·37	77·8	109	60	28·6	28·5	8·7	8·6	0·131	0·131	85	87	0·154	0·151
Railway and General	0·86	1·22	2·44	100·0	151	82	30·3	30·6	8·2	8·3	0·100	0·093	77	71	0·130	0·132
Davey-Paxman	1·00	1·07	2·28	68·0	68	63	16·4	13·4	7·2	5·9	0·117	0·094	100	89	0·117	0·106
Dowson	0·66	1·22	2·44	77·8	118	64	30·9	30·9	8·4	8·4	0·130	0·132	91	90	0·143	0·147
Campbell	0·79	1·39	3·60	78·0	99	56	24·4	21·5	5·4	4·7	0·122	0·108	79	72	0·155	0·150
Campbell (Throttle)	0·79	1·39	3·60	87·2	111	63	27·1	21·6	5·9	4·7	0·123	0·098	100	100	0·123	0·098
Dudbridge	0·79	0·79	1·45	74·1	94	94	19·6	19·7	10·7	10·8	0·108	0·109	79	78	0·137	0·139
Mersey	0·85	1·07	2·40	66·3	78	62	23·0	19·9	8·1	7·0	0·145	0·124	94	90	0·154	0·138
Hindley	—	—	—	94·0	—	—	—	—	—	—	—	—	—	—	—	—
Kynoch	1·00	0·54	0·96	79·6	80	147	18·4	18·0	19·2	18·8	0·116	0·113	90	83	0·129	0·136
Newton	3·19	0·92	1·84	66·3	21	72	5·7	—	9·9	—	0·137	—	94	—	0·146	—
Fielding	Revolving grate	0·66	1·32	81·8	—	124	—	—	14·0	14·2	0·113	0·114	81	81	0·140	0·141
Crossley	Special grate	Did	not run	—	—	—	—	—	—	—	—	—	—	—	—	—
Crossley	Special grate	0·79	1·58	62·6	—	79	—	—	9·7	8·8	0·123	0·110	93	87	0·132	0·126

AWARD OF THE JUDGES.

After full consideration of the observations recorded in this report, the judges arrived at the conclusion that the two plants which most satisfactorily fulfilled the regulations and commended themselves most for general purposes were the 20 brake horse-power plant exhibited by the National Gas Engine Company, Limited, and the 15 brake horse-power plant by Messrs. Crossley Brothers, Limited.

In order to discriminate between these two, a detailed examination was made of forty items, each of which was separately considered and marked, with the final result that the following award was made:—

Gold medal to the National Gas Engine Company, Limited, Wellington Works, Ashton-under-Lyne, for their 20 brake horse-power National gas engine, with 20 brake horse-power National suction gas plant. Catalogue No. 7.

Silver medal to Messrs. Crossley Brothers, Limited, Openshaw, Manchester, for their 15 brake horse-power gas engine and 15 brake horse-power suction gas producer. Catalogue No. 31.

GENERAL CONCLUSIONS.

It is evident from the results of the trials that many of the suction gas producer plants submitted for trial were quite satisfactory. There can be no reasonable doubt that with due care any of them would give satisfaction if employed for agricultural work as an "estate" engine. Although, however, less manual labour is required than in the case of a steam engine, more intelligent care is necessary to ensure the production of gas of good quality.

The economy trials confirm the results that have been previously obtained elsewhere, when the fuel required for banking and starting is taken into account. As regards the attendance, it is less than would be necessary for a steam engine and boiler, and not sensibly greater than what is needed by an oil engine of the same power under like circumstances. It may be said that, as regards reliability, the duration of the trials was insufficient to warrant a definite opinion; and undoubtedly only actual experience can show to what extent "clinkering" and "staging" of the fuel may be sources of trouble in the conditions under which such suction gas plants may have to run for agricultural purposes. It is interesting to note in this connection that the Dowson producer, working in conjunction with the Railway and General Engineering Company's engine, had been in use continuously for three months prior to the trials, and it was found, on close examination, that the condition of the furnace was quite satisfactory, and the amount of clinker firmly adhering to the fire-brick lining was very little. It is generally supposed that the fire-brick lining in a well-designed producer, that is, one in which the steam supply is properly regulated, ought to last about two years. The expense of replacing the fire-brick at such intervals cannot be regarded as a serious item of expense.

It is probable that suction gas plants will be able to replace portable steam engines for many purposes with distinct advantages both as regards handiness and economy.

A further step in advance will be made when a traction suction gas plant has been placed on the market. Another desideratum is a suction producer which will deal satisfactorily with bituminous coal. It is understood that several firms are experimenting with such plants, that successful results have been obtained already, and that at no distant date it may be possible to hold competitive trials.

(To be continued.)

THE Bavarian Government have appointed a Commission to report upon the exploitation of water power in that State. The Commission will inquire into the existing water power at present in use, and make suggestions and issue plans showing how further power can be accumulated and exploited. The Government is taking up the position that only such power may be used for industrial enterprises which is not required by the State itself, and will only grant concessions in such places where the water is not wanted for other purposes for the good of the community.

THE Clyde Trust have decided to adopt a recommendation of their Committee on New Works, that Elderslie Rock should be removed to a greater width than was originally contemplated under the contract, which is nearing completion. The contract bottom width of 200ft. is to be increased by taking 30ft. more off the north side at an additional cost at the present contract rates of about £5000. The contractor being still on the spot with all his special plant, it will be convenient to increase the bottom width of the channel, and so remove a barrier which has long been a source of trouble to the trustees and to navigation.

THE JUNIOR INSTITUTION OF ENGINEERS.—On Saturday afternoon, December 8th, on the invitation of the president, Mr. W. B. Bryan, M. Inst. C.E., Chief Engineer to the Metropolitan Water Board, a large number of members of this Institution paid a visit to the Honor Oak reservoirs, which are in course of construction for the Board, under the direction and supervision of Mr. J. W. Restler, M. Inst. C.E., by whom they were designed. Mr. Bryan, assisted by Mr. F. Melhuish and other members of the staff, conducted the party over the extensive works, pointing out the features of special interest. The reservoirs will contain nearly sixty million gallons of water, and will probably be the largest covered reservoir in the world. The construction generally is of brickwork and concrete, with walls separating the reservoir into four divisions. A middle wall 3ft. in thickness extends all round the outer walls, and is keyed into the clay. At the centre of the four reservoirs will be the central well from which the charging and emptying will be directed. The bricks used have all been made from the excavated clay on the site, sixteen million bricks so far having been produced. The existing engine-house and well pumps were also seen, and, at the conclusion, the president entertained the members to tea in one of the store-rooms. Moved by him and seconded by Mr. Geo. H. Hughes, a vote of thanks was passed to Mr. Restler and his staff for the arrangements which had been kindly made and carried out for the reception of the Institution.

A GRAPHIC WATER RECORDER.

A NEW water-recording instrument has lately been placed upon the market by Mr. James Lea, of 40, Brown-street, Manchester. This instrument measures and records graphically the variations in the rate of flow of water when flowing over weirs or through notches. The records obtained are of such a nature that, by finding the area of a plotted curve, the total volume of water that has passed over the weir during any particular time can be computed. The principle on which the instrument is based consists in combining the "curve of flow" with a float and pen, whereby

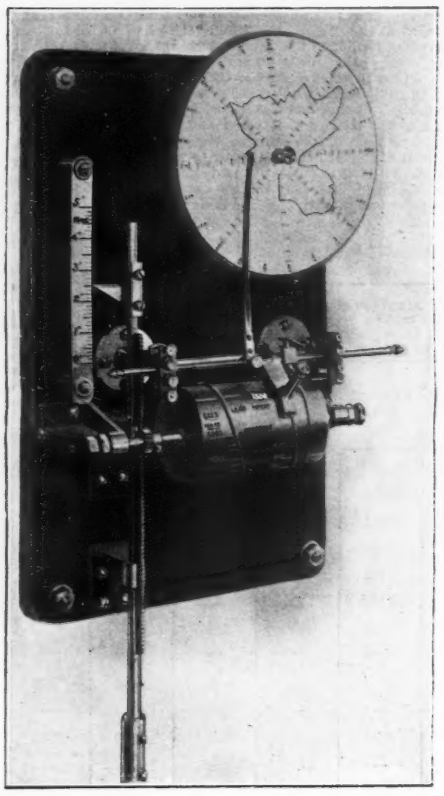


Fig. 1—LEA'S WATER FLOW RECORDER

diagrams are traced on records. This principle is not new. But Mr. Lea claims for his apparatus originality in the mechanical details and the possession of several features not embodied in other apparatus.

An illustration of the machine is given in Fig. 1, which shows the recorder without the case, and from this engraving a good idea of the working of the machine can be obtained. The whole installation comprises a recorder and a notched box—Fig. 2—tank, or weir, which contains a float. The former is connected to the float by a spindle, so that any vertical motion of the float causes this spindle to have a similar movement. There is a rack at the upper end of the spindle, which gears with a small pinion fixed to the axle of the drum. On the barrel of this drum a wire is wound in such a manner that it exactly follows the curve of flow plotted upon the surface of the barrel. Above the drum there is a sliding bar carried between rollers, which is free to move sideways. This bar carries the pen, and also a small projecting arm, the lower end of which engages with the wire by means of a small pivoted saddle block. The latter cannot move away from the wire on the drum, because it is held in position by a small guard

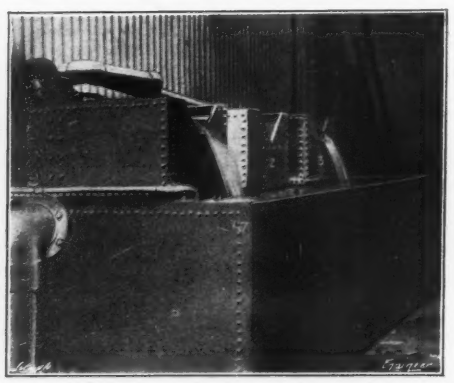


Fig. 2—MEASURING NOTCHES

arm which comes into contact with a fixed guard bar, should sufficient force be applied to lift the saddle out of connection with the wire. The wire on the drum commences with a very small pitch, which gradually increases towards the left-hand side, finally becoming zero again. This prevents any undue wear on the pointer when at either end of its travel. The vertical movement of the pen is also limited by stops, the coupling forming the bottom stop, and the rack the upper stop. The recording disc is held by a bracket above the lower drum, and it makes one revolution every twenty-four hours. The small scale shown in the engraving at the side of the rack indicates the height of the float in the weir.

The diagrams obtained record the ratio between depths of water in the weir and the corresponding ratio of flow. By finding the area of these diagrams with a planimeter the quantities of liquid passed through the weir or tank can be ascertained. On the drum which actuates the pen a scale is marked giving gallons per hour—or it might be marked off in any other units—that are passing through the weir. A small pointer which projects from the saddle arm shows at any instant the flow of the water. It is stated that fluctuations in the water level of $\frac{1}{100}$th part of an inch can be detected. A reduced facsimile of one of the records is shown in Fig. 3. This chart was taken from an apparatus used for the measurement of boiler feed water. The maker particularly recommends the instrument for this purpose, for, among other reasons, it enables the engineer to know exactly the quantity of water being pumped into the boiler, and, therefore, if the weight of coal used is also known, the evaporation of water per pound of coal at any time can be determined. However, the instrument can also be used to advantage for the measurement of the steam consumed by surface-condensing engines by obtaining the air pump discharge. The

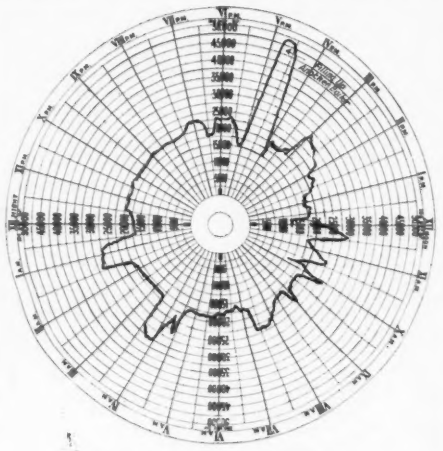


Fig. 3—RECORD OF BOILER FEED

engineer can then see at a glance what weight of steam is passing through the engine, and the weight of steam per indicated horse-power can then be readily determined if the engine is indicated. Any leakage in the condenser can also be detected. The engraving given in Fig. 4 is a reproduction on a small scale of a chart obtained from a recorder erected to measure the steam consumed by surface-condensing engines, and it is also arranged to show the indicated horse-power.

There are many other uses to which the recorders can be applied. For instance, there is the measurement of the supply of water delivered to a reservoir, the measurement of streams for irrigation purposes, and many other uses which will at once be apparent to the engineer. The apparatus is capable of recording the flow of other liquids besides water. It has already been installed at the East Rand Proprietary Mines at Johannesburg for measuring the cyanide solution In order to test the accuracy of the instrument, a series of experiments has been carried out, the results of which we

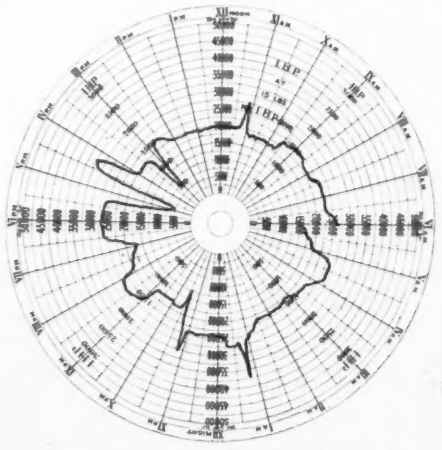


Fig. 4—RECORD OF STEAM CONSUMPTION

have before us. Seventeen separate tests were made, and altogether about 1600 tons of water passed through the notch at velocities varying from 4000 to 25,000 gallons an hour. The error of the records obtained is stated to be considerably less than 1 per cent.

CATALOGUES.

W. F. STANLEY AND CO., Limited, 4 and 5, Great Turnstile, Holborn.—The title of this pamphlet is "Some Notes upon a Method of Drawing with Modern Appliances."

DAVID ROWELL AND CO., 31-33, Queen-street, Westminster.—General catalogue of iron, wire, and other fencing, corrugated iron buildings, wire rope suspension bridges, horticultural buildings, &c.

TAYLOR AND CHALLEN, Limited, Birmingham.—1906 catalogue of presses, dies, shears, lathes, &c., for sheet metal work. The book comprises 200 pages of well printed text and illustrations, and has an admirable index.

SIEBE, GORMAN AND CO., Limited, Westminster Bridge-road, London.—Catalogue of specialities in small, portable, and stationary air pumps, compressors, and vacuum pumps driven by hand, belt, steam, or oil engine, or electric motors.

JOHN G. STEIN AND CO., Limited, Bonnybridge, Scotland.—This pamphlet serves the double purpose of illustrating the company's works, and giving particulars of the special kinds of firebricks which are there made. These are known as the "Thistle" brand, and are made from the Glenboig seam of clay.

PROPOSED HARBOUR OF REFUGE INQUIRY.

No. II.*

PORT QUIN is one of the sites for a harbour of refuge, either for national or coasting traffic, which has been from time to time referred to in the locality. The bay is almost central on that long length of dangerous coast which extends from Hartland Point to Land's End. Its configuration is such that considerable natural protection is afforded by the headland forming the western horn of the bay, known as Cliff Castle, and also by the outlying Mouls Island. The Sound between the south-west salient point of the latter and the north-east projection of Cliff Castle is nearly 900ft. in breadth, and has a maximum depth therein of 6½ fathoms at low water of spring tides. Fig. 3 illustrates the following remarks, both with regard to Port Quin and Padstow, which lie, as will be seen, almost adjacent to each other, Padstow Bay and Port Quin Bay being separated by Pentire Head and the coast extending between it, and Rumps Point and Cliff Castle. The bed of the bay is generally sandy on the surface, but in the Sound between the mainland and Mouls Island, where there is a considerable current, and not infrequently an extensive range of the sea, the bed is rocky, as might be expected. Vessels have occasionally found refuge in Port Quin Bay during gales, and it may be concluded that the holding ground is good.

An extremely heavy sea passes through the Sound between Cliff Castle and Mouls Island during north-west gales, which action is intensified by the funnel-shaped approach formed by the converging cliffs of the headland and the island. Notwithstanding the exposure of the Sound and the entering of heavy seas into the bay through the same, I am of opinion that it would not be prudent, in the event of a harbour of refuge being constructed at Port Quin, entirely to close this gutway, in consequence of the danger which would thereby be incurred of sand deposits within the enclosed area, owing to the absence of sufficient circulation therein. I have given this matter careful thought, and in view of the configuration of the sands in the adjacent Padstow Bay, have no hesitation in arriving at the foregoing conclusion. The current in Port Quin Bay runs to the westward through the Sound for nine hours out of twelve, thus constituting a valuable feature in favour of the site, so long as a sufficient waterway remains in the Sound to permit of the tidal circulation thus set up.

It has been alleged as an objection to Port Quin that there is no beach on which a vessel could run, in the event of her fouling her anchor, when seeking refuge in a harbour there, and also that no facilities exist for effecting repairs to vessels, or for renewals of either gear or provisions. Should, however, a harbour be constructed at Port Quin, it may be assumed that not only would it soon be connected with the railway system, but that a settlement would grow up in the vicinity which would meet the requirements. The new branch line could be connected with the North Cornwall Railway at Port Isaac-road Station, and would extend to the western margin of Port Quin Bay, thus being about 6½ miles in length. With reference to a vessel fouling her anchor and getting on to the rocks to leeward, this would not appear to be a probable contingency, in view of the extent and character of the shelter which would be afforded. It will be observed on referring to Fig. 3 that to form a refuge harbour at Port Quin it is considered necessary to construct a breakwater extending generally in an E.S E. direction, from the eastern face of Mouls Island for a length of 2300ft., and also the partial closing of the Sound by the construction of two spurs, each of 250ft. in length, one from the north-east point of Cliff Castle, and the other from the south-west salient point of Mouls Island, leaving an opening between the two ends of the same of 400ft., thereby establishing sufficient circulation to prevent sand deposits within the enclosed area, and shutting out the sea to a corresponding degree. The cost of these works would be about £812,000, the sheltered depths being from two to seven fathoms at low water of spring tides, the areas so protected 310 acres in north-west winds, 180 acres in northerly winds, and 120 acres in north-east winds.

The site at Port Quin does not lend itself to the construction of a small harbour for coasting or fishery traffic, although the conditions are suitable for the installation there of a harbour of refuge, which would be available for national shipping if in distress or requiring shelter off this stretch of coast. At the same time adequate protection for coasting and fishery traffic would be afforded within the National Harbour.

Padstow has been the subject of previous investigations and proposals. Its central position between Land's End and Hartland, and the fact of there being a depth of 11ft. in the entrance at low water of spring tides, are favourable features. On the other hand, there are the dangers arising from baffling winds which sweep around Stepper Point; the very narrow entrance to the Channel; the strong currents running seaward during ebb tides; and the Doom Bar, upon which so many vessels and lives have been lost. During spring tides the ebb stream runs strongly out of the harbour, and several wrecks have occurred through vessels attempting to enter on a falling tide with scant wind. As previously named herein, the Royal Commission of 1859 recommended an expenditure of £20,000, in the first instance, for the partial cutting down of Stepper Point, with a view to removing the difficulties which existed in consequence of the baffling winds on the Channel side, the ultimate cost of such removal, to the extent necessary being £40,000. The grant for carrying out this rock-cutting has not been obtained, although a small portion of the Point has been removed, payment for the same being made out of the sum of £1100 borrowed from the Public Works Loan Commissioners. The benefit from the removal of this small amount of rock is stated locally to be very real, although at the time of my visit I noticed that the effect of such removal was being nullified by the deposit of quarry *débris* on the lowered rock bed previously formed, thereby causing a corresponding increase in height, and forming an obstruction to the free action of the wind. Quarrying at Stepper Point is still proceeding, but at a slow rate, and with no likelihood of any beneficial change being produced, at all events for a considerable period.

A proposal was made in 1862, which was supported by evidence given before the Select Committee in 1884, to direct the currents in the vicinity of the entrance by constructing a training mole on the Doom Bar sand. This proposal must have been extremely inadequate, inasmuch as the estimated expenditure was from £20,000 to £25,000. The line of this work is shown in Fig. 3 by dotted lines.

Having regard to the extent of the sand deposits in Doom Bar and in the entrance to the harbour, and also in the embayment between Pentire Head and Trebetherick Point, including Polzeath Beach, I am of opinion that the results which would follow from the construction of works of the character necessary for excluding the sea and for training the current in the entrance, say by a mole from Bray Hill, extending over Doom Bar and on to the Ketch Sand, or a portion of the latter, would be extremely doubtful. Moreover, although sand would be removed on the harbour side of such a work, outlying spits seaward of such mole, and possibly also of Stepper Point, would not improbably be produced, in which event the difficulties now experienced, instead of being removed, would be considerably intensified. After careful study of the physical conditions of this port, I regret to report that it is not, in my opinion, suitable for a harbour of refuge, nor could it be regarded as comparable with other sites on the coast, as a port which is capable of improvement, in order to afford such protection as is required for coasting traffic, and to constitute it the headquarters of the fisheries which are conducted off this coast. The extended use of Padstow by trawlers will no doubt further develop, seeing that railway facilities exist there for landing and forwarding fish to market. Inasmuch as considerable benefit would result from the cutting down of Stepper Point to the extent recommended by the Royal Commission, I am of opinion that this should be done, and

* No. I. appeared December 7th.

PROPOSED HARBOURS OF REFUGE

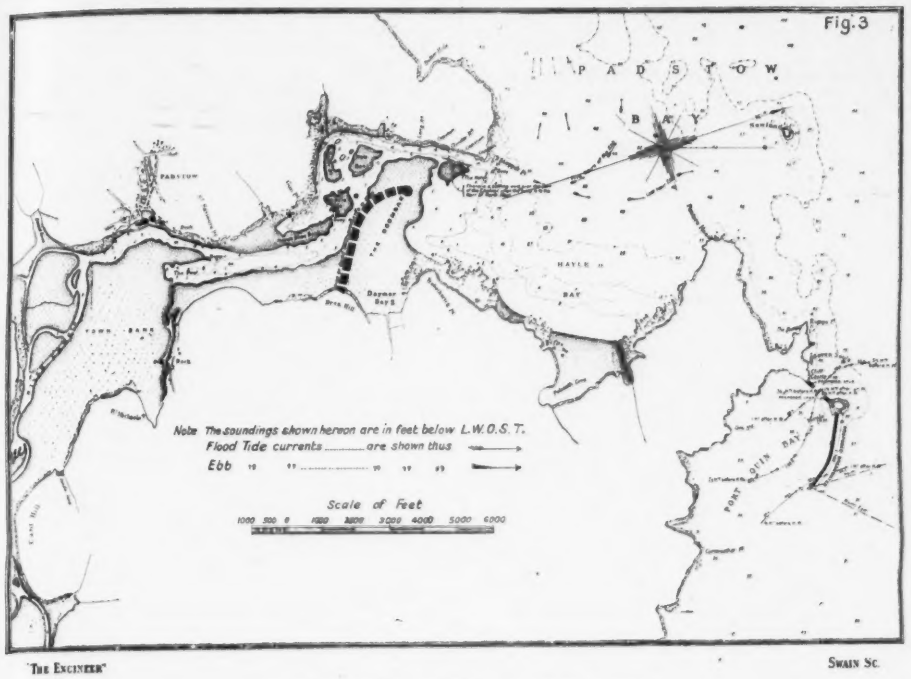


Fig. 3—PROPOSED HARBOUR AT PORT QUIN

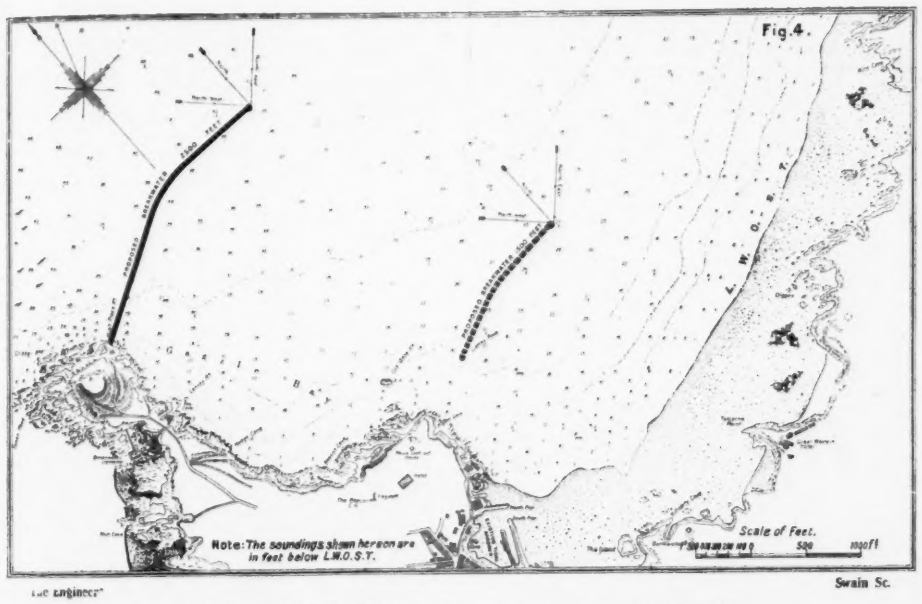


Fig. 4—PROPOSED BREAKWATER AT TOWAN HEAD AND LISTREY ROCK

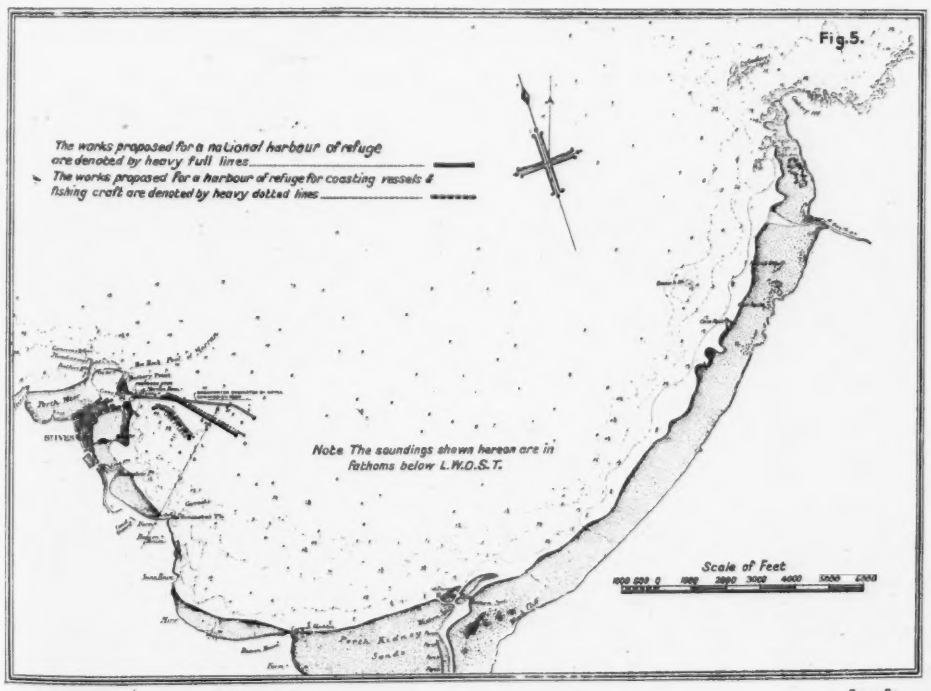


Fig.5.
The works proposed for a national harbour of refuge are denoted by heavy full lines
The works proposed for a harbour of refuge for coasting vessels & fishing craft are denoted by heavy dotted lines
Note The soundings shown hereon are in fathoms below L.W.O.S.T.
Scale of Feet
Perch Rock
Perch Kidney Sands
"THE ENGINEER"
SWAIN Sc.

Fig. 5—PROPOSED BREAKWATERS AT MERRAN ROCK

that great advantage in the approach to the harbour would result therefrom.

Fig. 4 shows by dotted lines a sheltering breakwater extending from High Place Rock, at Towan Head, in a north-east direction for a length of 1200ft., trending from thence on a curve to the eastward, followed by a straight arm almost east and west, the total length of the work being 2500ft. The depths which would be sheltered by a breakwater of this description are 240 acres in north-west winds, 103 acres in northerly winds, and 42 acres in north-east winds. It will be observed that the work would shelter Gazzle Bay.

I do not regard Newquay as so favourable or suitable a site for a national harbour of refuge as Port Quin. It does not offer the the same facilities as the latter for vessels unable to weather Trevose Head, and, moreover, lies further back from the last-named headland than Port Quin. In addition to the foregoing, there are, in my opinion, sufficient grounds for believing that if a harbour were constructed at Newquay the sheltered depths created thereby would not be self-maintained, in view of the enormous quantities of sand in Fistral Bay, which, on the occurrence of onshore gales, would be stirred up by the waves breaking thereon, and not improbably travel north-east with the flood tide, causing a deposit under the lee of the work. I estimate the cost of this breakwater at £800,000 It would have to be an extremely massive work, and well constructed, seeing that it would be exposed to what would practically be the full force of Atlantic waves. By leaving an opening for circulation between the High Place Rock and the inner end of the sheltering work, the reduction of the sheltered depth, in consequence of sand deposits, wou'd not improbably to some extent be diminished, but not sufficiently so to produce satisfactory results, and at the same time the area sheltered would be less. Coasting vessels do not use Newquay for shelter, for fear of being caught by northerly winds following on south-westerly gales. The heaviest seas at Newquay are experienced on the veering of the wind to north-west after blowing strong from south-west. North-east wind does not bring in much sea, the dangerous arc being from W.N.W. to N.N.E. The holding ground is said to be good. Vessels from Liverpool in trouble during a south-west gale have been known to be driven up towards Trevose Head.

I have shown by full lines on Fig. 4 a smaller arm, extending generally in an easterly direction from Listrey Rock, a submerged patch lying off Pigeon Cove. The length of the work, as indicated on the plan, is 1500ft., and its cost is estimated at £360,000. It would also be necessary that this work should be strongly proportioned and well put together, in view of the heavy seas which would fall on it. Its cost would be increased by reason of its being isolated, consequent on leaving an opening for circulation between its inner end and the rock headland. Without such opening the work in question would undoubtedly produce accretions of sand under its lee. As laid down, however, even with the opening as indicated, it is believed that the probabilities of shoaling are so great that the considerable expense which would be involved in the construction of the work would not be justified. The construction of a deep-water harbour at St. Ives has been the subject of much investigation and many reports. The Select Committee of 1858 recommended an expenditure of £174,000 in the construction of a breakwater 2000ft. in length, a sum which is manifestly inadequate for the execution of the work contemplated.

The Royal Commission of 1859 stated their belief that the claims of St. Ives were paramount to all others, and recommended the expenditure of £400,000 for the construction of a breakwater 3750ft. in length, which was shown on a plan attached to the report. This estimate is also entirely insufficient, and was based on a section consisting of external walls filled in with a hearting of loose rubble, a mode of construction which would certainly have proved disastrous, in view of the heavy seas to which such a work on the line recommended would have been exposed. Since 1859, in consequence of the extensive use of Portland cement, the more perfect plant and appliances now available for handling concrete blocks of considerable weight, and the diminished sea risk and liability to accident during construction which would follow from the adoption of a solid work, instead of one consisting of external walls filled in with loose rubble, would now be considered as affording sufficient advantages to justify the putting forward of an entirely solid structure of concrete blocks instead of the "pocketed" work contemplated in the estimate of the Royal Commission. The last-named work was intended to have been continuous from the shore, without an opening for circulation, and was to have commenced just southward of Merran Rock. Since this proposal was made, what is known as a "crib work" pier, consisting of external timber piling filled in with rubble, has been constructed from near the root of the old Smeaton Pier. This work was commenced in 1864, and after spending about £17,000 upon it up to 1867, it was not further proceeded with. In 1881, or just subsequent thereto, this pier was practically destroyed, only the dispersed rubble hearting and a few pile stumps now remaining to mark its existence. The work, however, stood for a sufficient period to show that sand accumulated on its landward side, in the same ratio as the pier advanced seaward, a result which would also have inevitably followed the construction of the continuous breakwater recommended by the Royal Commission. The Select Committee of 1884 did not determine between the relative advantages of the ports which had been brought to their notice. The only place, however, which they mentioned favourably on the north coast of Cornwall was St. Ives.

In Fig. 5 I have shown by heavy full lines the position of a breakwater 2500ft. in length, extending from just off the Merran Rock, commencing on a curve generally in an E.S.E. direction, and subsequently trending towards Hayle Bar. The depth immediately under the lee of this work would be from 7 to 8 fathoms at low water of spring tides, and sufficient shelter would be afforded by it to constitute a national harbour of refuge. During south-west winds the area between it and Porthminster Point would be completely sheltered. When north winds prevail there would be 200 acres sheltered outside the three-fathom limit, and 115 acres during north-easterly winds. The holding ground is stated to be good. On the Feather Bed Rock, just south of Merran, it is proposed to construct a spur, the outer end of which would be 500ft. landward of the western end of the proposed breakwater, thus leaving an opening to that extent for circulation purposes. Seeing that a current would run through it for nine hours continuously each tide in a northerly direction, it should prove effective in maintaining the depth under the lee of the breakwater, at all events, with little or no aid from maintenance dredging.

Before the construction of any actual work at St. Ives is undertaken, a detailed survey, with special information as to currents, littoral and otherwise, would be necessary, more particularly in connection with the accumulation of sand, consequent on the erection of the old crib work pier, and the extent and configuration of the sand deposits on the foreshores and sea bed. The estimated cost of the breakwater, shown by heavy full lines in Fig. 5, is £847,000, including the spur on the Feather Bed Rock. The breakwater would be constructed as a solid work, founded on a rubble base, the footings on the latter being protected by heavy wave-breaker blocks of concrete. On the same sheet is also shown by dotted lines, as an alternative proposal, a sheltering arm for the formation of a harbour, available for use by coasting vessels and fishing craft for refuge purposes, in the event of a national harbour not being proceeded with. This last-named breakwater would likewise be formed as an isolated work, leaving an opening between its western end and the shore. The breakwater itself would be 1500ft. in length, and its cost, including the spur on the Feather Bed Rock, is estimated at £400,000. This expenditure could be reduced by moving the position of the arm further westward, in which event the sheltered area and depth would be correspondingly decreased. St. Ives has special claims for con-

sideration on account of the extent of its fishing industry, which is by far the most important on the north coast of Cornwall.

It will be concluded from the foregoing remarks that I am of opinion the two most favourable sites on the north coasts of Devon and Cornwall for the construction of a national harbour of refuge are Port Quin Bay and St. Ives Bay. Port Quin is more centrally placed than St. Ives; but the latter is conveniently situated for refuge purposes with regard to the Land's End, and the enormous traffic in shipping in its vicinity, including not only the traffic from the Bristol Channel and the Welsh coal ports, but also that to and from Liverpool and the Irish ports. Again, there is the further argument in favour of St. Ives, viz., the prevalence of wrecks there, as shown on the chart which accompanied Commander Frederick's Memorandum. I consider, therefore, on the whole, that St. Ives is the preferable position to adopt for a national harbour of refuge. The same remark applies with regard to the best position for a harbour for the accommodation of the coasting traffic, and for fishery purposes, and where a sufficient depth of sheltered water would be available under all conditions of weather and tide. It will be observed that the foregoing recommendations are generally in accord with those put forward in the report of the Royal Commission of 1859.

At Padstow considerable benefit would be derived from the cutting down of Stepper Point, as recommended by the Royal Commission. Further advantages would follow upon the utilisation of the materials thus rendered available in the construction of internal training banks, with a view to regulate and maintain a more uniform depth than at present in the channel within the harbour. The estimates which are given herein may not improbably be considered as unnecessarily excessive. In view, however, of the magnitude of the works contemplated, their great height and the abnormally heavy seas which would fall on them, I do not consider it prudent to calculate upon a less expenditure being necessary than named, for the satisfactory carrying out of the works described. At St. Ives, the national harbour, as an alternative to the local and fishery harbour, would be exposed to a wave stroke of less intensity than at the other sites named, consequent upon the lines which have been selected for the structures referred to, and which have been practicable at this spot. Detail surveys would, of course, be necessary, on which the final designs would be based. When the latter have been prepared, an opportunity will be presented for a reconsideration of the precise character and extent of the works which are necessary, and their probable cost. It may, however, be taken that the estimates as given herein are sufficiently approximate for the purposes of this report.

I consider that a harbour of refuge is necessary for the coasting and fishing industries, because there is no satisfactory harbour at present on the north coast of Cornwall and Devon to which vessels engaged in local trade and also the fishing craft can run with safety during north-west and northerly gales at all states of the tide. If such a harbour were established, there is reason to believe that the fisheries on the north coast would be benefited, as they have been by the construction of the harbour at Newlyn in Mount's Bay. Statistics of wrecks and casualties have been given, and references made to the conditions associated with the navigation off the coast under consideration. St. Ives appears to me, on the whole, to be the most suitable site for the establishment of the harbour, and the approximate cost of the necessary works has been stated. Replies have also been furnished, in the descriptions and plans of the respective works, to the special instructions referred to in heads I. and II. With reference to head III., I consider that if a national harbour were established at St. Ives, accommodation would at the same time be provided for coasting vessels and for fishing craft.

Glasgow Technical College Scientific Society.—At the usual fortnightly meeting of this body held in the College on the 8th inst., Mr. W. W. Lackie presiding, Mr. David Carlaw, of David Carlaw and Sons, Glasgow, read a paper on "Newspaper Printing Plant." He gave a *résumé* of the history of the modern printing press, which, he said, had developed from a machine that could print 500 copies of a newspaper per day to the machine of the present time, which turned out 50,000 copies per hour. The first idea of the modern rotating cylindrical machine he traced to William Nicholson, who, in 1790 patented, but never made, a machine which foreshadowed nearly every fundamental element of the most advanced machine of the present day. Mr. Carlaw's paper was illustrated by a number of interesting slides showing the various types of machine at present in use. An interesting discussion followed.

Test of a Steam Turbine.—Experiments were made in June, 1906, by Professor Schröter, of Munich on a 500-kilowatt Melm and Pfenninger steam turbine. In this turbine the steam is first passed through several vane rotors, the pressure being kept uniform, then through another series at a much higher—super—pressure. The axial thrust along the shaft is taken by means of a circular passage between the two sets of vane rotors, where the pressures practically counteract each other. Seven experiments were made, six from full load to empty with the turbine coupled to the two dynamos, the seventh on the turbine alone. Each trial lasted an hour. The temperatures and absolute pressures of the steam were taken in the usual way, in seven places from admission to exhaust, and in the air pump chamber. The temperatures of the cooling and condensation water and the electrical efficiency were also determined. The consumption of steam was measured from the condensation water. Both the air pump and the centrifugal pump to the surface condenser were driven electrically. The steam was superheated, and the smaller the load the greater the superheat it retained at exhaust. At full load the temperature of the steam on entering the turbine was 607 deg. Fah., temperature of saturation 377 deg. Fah., or 230 deg. Fah. of superheat. At exhaust the steam at full load had 1 deg. of superheating, showing that it was perfectly dry. When the turbo-dynamo was run without load the steam was discharged with 170 deg. Fah. of superheat. The efficiency of the dynamo at full load was 90·6 per cent., and of the dynamo and turbine combined 83 per cent; consumption of steam, 17·1 lb. per kilowatt hour; and 10·4 lb. (calculated) per indicated horse-power hour, minimum value.

Professor Gray on Speed of Vehicles on Curves.—Before the Royal Philosophical Society of Glasgow on the 5th inst., Professor Gray, of Glasgow University, read a paper on "The Limiting Speed of Vehicles Moving on Curves, and the Effect of the Gyrostatic Action of the Wheels on Stability." He discussed the theory of the overturning of carriages in passing round curves, and applied the results to particular cases—among others to the explanation of the recent accident at Salisbury, on the London and South-Western Railway. He gave a table of the limiting speeds for various super-elevations of the outer over the inner wheels of the vehicle on the curve, that is, of the speeds at which for these elevations the inner wheels just ceased to press on the rail or the ground, and at which the vehicle was on the point of overturning. As it had been suggested by some writers that the gyrostatic action of the wheels of the vehicle is of importance, Professor Gray dealt with this point, and showed that though gyrostatic action tended to overturn the vehicle, its influence was comparatively slight. He worked out its approximate amount for the four large wheels—drivers and trailers—of the London and South-Western locomotive from data supplied to him by Mr. Wm. Lorimer, of Messrs. Dübs and Co., who built the engine. The diminution of the limiting speed was found to be only about $1\frac{3}{4}$ per cent. of the limiting speed found without taking the gyrostatic action into account. The limiting speed for the engine at Salisbury came out about sixty-six miles per hour; that is to say, at that speed the whole weight was borne by the outer wheels. Such a speed, therefore, was critical, and was far above that which should have been adopted at the spot.

AUSTRALIAN NOTES.

Sydney Tramway Employés.—For some considerable time past trouble was brewing among the drivers and conductors owing to alleged grievances they contended they were suffering under. At last the Premier appointed a board of three independent gentlemen to thoroughly investigate into their charges. Among the principal items of grievances were:—(1) Complaints generally with regard to the Appeals Board. (2) The refusal to pay increments as per classification sheet or by-laws in certain cases. (3) The disallowance of good conduct holidays in whole or in part, in certain cases. (4) The system of espionage in force in connection with the tramway service, with its many harassing and objectionable features. (5) The failure of the Newell-Westinghouse magnetic brake. (6) The discrimination as between members of the staff, and with regard to change of duties, which operate to the prejudice of some. (7) Punishments imposed for offences, or alleged offences, and anomalies disclosed. (8) Abuses of authority and position by certain officers of the department. (9) Promotions to higher grades, and appointment to the service, and the general practice therewith. (10) Protection to drivers from the weather. (11) Matters generally. The Board sat continuously for eighty-four days and have now furnished their report, and have not found any of the charges proved; the only recommendation suggested by the Board is on subject 10, where they recommend glass shields should be affixed in front of the cars for the protection of the drivers.

Reductions in N.S.W. Railway Rates.—As a result of the successful working of the New South Wales last financial year, the Commissioners have already reduced the rates on a number of commodities. Grain, flour, and agricultural produce, carried long distances, have been reduced as much as 2s. per ton; nearly all third-class traffic has been placed to second-class, and it is contemplated that the passenger season tickets are to have immediate consideration. The prospects of the season so far point to another record for the coming year.

Gold Stealing.—Proceedings have been running on for some considerable time in the courts at Kalgoorlie, W.A., over gold stealing in several of the mines there. It has been clearly proved by the detectives that certain workmen had very large sums to their credit in the banks—the gold surreptitiously taken being bought by unauthorised dealers. It is advocated that all buyers of gold be licensed. It was given in evidence that some of the mines did not give a return sufficient to pay a dividend, were very rich, but the gold stealing could not be stopped.

Western Australia Transcontinental Railway.—Since the Commonwealth Parliament has shelved the Bill for the construction of a line from the Eastern to the Western State, the Western Australians have been up in arms about it. Lectures have been delivered throughout that State threatening to secede from the Federation owing to the betrayal of the Union in not securing the construction of the line.

Minerals.—The coal output in the Newcastle and Maitland districts of New South Wales continues flourishing. The coal exports for the nine months of this year show an increase of 950,051 tons, valued at £429,508.

Iron and Steel Manufacture in New South Wales.—Great preparations are being made by W. Sandford, Limited, of Lithgow, in getting ready the plant for the manufacture of iron and steel. The firm has secured the contract for any iron or steel articles required in any of the Government departments, commencing on January 1st next, and as this is the first attempt of any importance to manufacture iron in the State, the result will be watched with interest.

The Institution of Mechanical Engineers—Graduates Association.—The third general meeting was held at the Institution, Storey's-gate, Westminster, S.W., on Monday, December 10th, 1906, at 8 p.m., Mr. Mark Heaton Robinson, member of Council, in the chair. The minutes of the second general meeting were read, approved, and signed by the chairman. A paper entitled "Up-to-date Milling Machinery" was presented and read by Mr. A. B. Symons, Graduate, of London. Mr. H. G. Duncan opened the discussion, in which the following graduates took part:—Messrs. Cartwright, Laird, Petrie, Cheeseman, Hodgson, Walker, Salway. The meeting concluded with a vote of thanks to the chairman. Attendance: Graduates, 30; visitors, 17.

Institution of Civil Engineers: Glasgow Association of Students.—At the second meeting of the session of the Glasgow Students' Association of Civil Engineers held on the 3rd inst., in the Institution Rooms, Bath-street—Mr. Donald A. Matheson, president, in the chair—Mr. F. A. Macdonald submitted a paper on "Ferro-concrete Construction." The subject being one of outstanding interest at present to engineers and architects, there was a large attendance. The author dealt first with the technics of the design of ferro-concrete work, and proceeded to demonstrate the advantages of ferro-concrete over other building materials, at the same time pointing out the absolute necessity for good workmanship in dealing with the material, if the best results were to be obtained. An illustrated description was given of a number of works executed both in this country and on the Continent. An interesting discussion followed.

The Railway Club.—This club held its annual dinner at the Holborn Restaurant on Wednesday last, the 12th inst. The function was well attended, and was presided over by Mr. C. H. Faraday. The membership of the club now numbers 155, and is displaying considerable vitality; 40 new members have been elected during the past year. The president is the Rev. W. J. Scott, B.A., and the headquarters are at 92, Victoria-street, London, S.W., where a library is provided for the members. A magazine, edited by Mr. R. E. Charlewood, is also published monthly. The society's aim is chiefly non-technical, but it is capable of doing good service in educating the lay mind with regard to railway organisation and management.

International Congress on School Hygiene.—The second International Congress on School Hygiene is to be held in London from August 5th to 10th next year, under the distinguished patronage of his Majesty the King. The question of school hygiene is of considerable importance in preventing deterioration and promoting the health and physical development of children, and also in enabling them to profit by the instruction given in the school. The work of the Congress will be divided into eleven sections, presided over by an eminent authority on the subject dealt with. The subjects will be:—"The Physiology and Psychology of Educational Methods," "Medical and Hygienic Inspection of Schools," "The Hygiene of the Teaching Profession," "Instruction in Hygiene for Teachers and Scholars," "Physical Education and Training in Personal Hygiene," "Out-of-school Hygiene, Holiday Camps and Schools, the Relation of Home and the School," "Contagious Diseases, Ill Health, and other Conditions Affecting Attendance," "Special Schools for Feeble-minded and Exceptional Children," "Special Schools for Blind, Deaf, and Dumb Children," "Hygiene of Residential Schools," and "School Building and its Equipment." In order to illustrate practically matters coming under the consideration of the Congress, an exhibition will be organised and arranged in the University Building by the Royal Sanitary Institute, in which the planning, construction, and equipment of school buildings will be illustrated, and school furniture and teaching appliances of all kinds illustrated. All particulars and the preliminary programme can be obtained from either of the hon. general secretaries, Dr. James Kerr, M.D., M.A., D.P.H., and Mr. E. White Wallis, F.S.S., at the Royal Sanitary Institute, Margaret-street, W.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Advance in Marked Bars.

The most characteristic movement at the moment in the trade boom here is the advance in Staffordshire marked bars which was announced on Friday of last week. This is the first advance which has taken place since the boom set in. Last July, indeed, there was a reduction of 10s. per ton, but it came at a very odd moment, since almost directly afterwards the revival showed itself. The makers have now put on the 10s. they then took off. Staffordshire marked bars are now once more £9 for all the leading makers, and £9 12s. 6d. as the Earl of Dudley's quotation for L.W.R.O. iron. The official advance of 10s. in bars carries with it a similar advance in plates and sheets rolled by the "list" iron houses. A change in the standard so near the end of the year is most unusual, and argues the revived condition of the market. Messrs. John Bradley and Sons' minimum for bars becomes £1 0 per ton.

Common Bars Advanced.

The expectation mentioned in last week's report of an immediate rise in unmarked bars has also been fulfilled. The Unmarked Bar Association have officially announced such an advance, making the minimum £7 10s., and North Staffordshire bars have been increased by a corresponding advance to the same price. This figure was firmly quoted at to-day's (Thursday) market, and, in view of the 5s. rise in South Yorkshire and Lancashire, there was a determination to accept nothing less.

Other Prices Quoted Up.

Thin steel strips to-day on the Birmingham Exchange and also iron hoops were both advanced to £8 10s. per ton, and gas tube strip 7s. 6d. per ton, making the basis £7 10s. to £7 12s. 6d. An increase of 5s. per ton was announced in sectional steel for bridgework and railway wagon building, bringing steel engineering angles up to £7 and £7 5s. per ton.

Sheet Iron Inflated.

The sheet iron trade is inflated, and makers are full of orders and are refusing additions to their books. Anything like early delivery is an impossibility in the present state of the demand. Prices are peculiarly firm and buoyant. Doubles, *i.e.*, sheets of 24 w.g., cannot this week be bought under £9, and many firms quote £9 2s. 6d. and £9 5s. Trebles are £9 12s. 6d. minimum to £9 15s. and £9 17s. 6d., and singles £8 17s. 6d. to £9 per ton. Galvanised corrugated sheets have again overtaken the Association minimum by 5s. to 10s. per ton, and the selling price now ranges from £13 5s. per ton to £13 15s. per ton.

1907 Trade Prospects.

It has been a long time since there was so general and forward a movement in iron and steel prices on Birmingham Exchange, and as the works are all running to their full output and are unable to overtake the orders on their books or to keep pace with the new demand, there is a growing conviction that a very busy time is before the trade for 1907.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

Manchester, December 12th.

Pig Iron Position becomes More Acute.

The attendance on the Manchester Iron Change on Tuesday was larger than ever. As the month progresses, the position of pig iron becomes more tense, and merchants and consumers show much concern as to the future. Advances seem to come as a matter of course, in view of the large demand for export. Merchants say there is very little iron to be got, and makers confirm this to a great extent by stating they have none to offer, and in most cases quotations have been withdrawn. Scotch iron shows an advance of 2s. to 3s.; hematite, 3s. to 4s.; while other makes are 1s. 6d. to 2s. 6d. more money. Lincolnshire grades were formally advanced 1s. 6d. per ton, but a premium to this extent had already been paid locally. Lancashire remains nominally unchanged, but makers had none to offer. Staffordshire was 1s. dearer, making an advance of 3s. per ton since the beginning of the month. Middlesbrough did not show much change. Forge iron shows an improvement of 1s. per ton for East Coast. Scrap iron is being eagerly bought up, and brings high prices.

Finished Iron.

The recent advance of 5s. per ton for bars, &c., seems to have been a mere sop to the trade. It was readily paid by consumers, and, by the time these notes appear, it is more than probable that another advance of 5s. will have been agreed to by the Makers' Association.

Steel.

All products of steel are in strong request and another advance is imminent. At the time of writing, however, we have no official change to report.

Manufactured Copper.

Following continued advances in raw copper during the past week another advance was declared late on Tuesday afternoon. Sheets went up £2 per ton, and tubes were also fractionally dearer.

Quotations.

Pig iron: Lancashire No. 3 foundry, 64s.; Lincolnshire, 65s. 6d. to 66s.; Staffordshire, 66s.; Derbyshire, 66s. 6d. to 67s.; Middlesbrough, open brands, 71s. 10d. to 72s. 4d. Scotch: Gartsherrie, 76s. 6d.; Glengarnock, 75s. 6d.; Eglinton, 74s. 6d.; Dalmellington, 74s. 6d., delivered Manchester. West Coast hematite, 78s.; East Coast ditto, 77s. 6d. to 78s., f.o.t.; Scotch, delivered Heysham: Gartsherrie, 74s. 6d.; Glengarnock, 73s. 6d.; Eglinton, 72s. 6d. Delivered Preston: Gartsherrie, 75s. 6d.; Glengarnock, 74s. 6d.; Eglinton, 73s. 6d.; Dalmellington, 73s. 6d. Finished iron: Bars, £7 10s.; hoops, £7 17s. 6d.; sheets, £8 7s. 6d. to £8 12s. 6d. Steel: Bars, £7 10s. to £7 15s.; hoops, £7 17s. 6d. to £8; boiler plates, official, £8 12s. 6d.; plates for tank, girder, and bridge work, £7 10s. to £7 15s.; English billets, £6 5s. to £6 15s.; sheets, £8 12s. 6d. Copper: Sheets, £120 to £122; tough ingot copper, £109 10s. best selected, £110 to £112 per ton; seamless copper tubes, $14\frac{1}{2}$d.; brazed ditto, $13\frac{1}{2}$d.; seamless brass tubes, 11d.; brazed ditto, 12d.; condenser, 12d.; brass wire, 10d.; rolled brass, $9\frac{1}{2}$d. to 10d.; brass screwing rods, $9\frac{1}{2}$d. to 10d. per lb. Sheet lead is steady at £22 5s. per ton. Tin: English ingots, £197 10s. per ton.

Lancashire Coal Trade.

The attendance on the Manchester Coal Exchange on Tuesday was well up to the average. The hopes of the members had been raised by the sharp frost of the previous two or three days in anticipation of a better demand for house coal, but that very morning a thaw set in, and business in this department was therefore very restricted in character. On the other hand, demand for slack and manufacturing coal was exceedingly good, and on shipping account holders asked somewhat more money. Full time is being worked at the collieries, and prospects forward are

exceedingly good. Ordinary quotations are:—Best coal for domestic purposes, 14s. to 15s.; seconds, 13s. to 13s. 6d.; common, 9s. 6d. to 10s. 6d.; best burgy, 8s.; best slack, 7s. to 7s. 6d.; medium, 6s. 6d. to 7s.; common, 5s. 6d. to 6s. at the pit. Screened coal for bunkering purposes, 10s. 6d.; unscreened, 9s. 6d., delivered Manchester Ship Canal.

BARROW-IN-FURNESS, December 13th.

Hematites.

There is a further marked improvement in the hematite pig iron trade this week, and the prophecy that prices would soon reach 80s. per ton has already been realised, for warrant sellers have done considerable business at that figure, and it seems probable that further advances will soon be made, as the demand is very much larger than the capacity of makers to supply. Makers, in fact, are quoting mixed Bessemer numbers at 83s. per ton net f.o.b., and in many cases they are refusing to issue prices, as they find they can sell almost any amount of iron without going into the market to find buyers. It is plain to be seen that there is now a famine in the market, as makers have not any available iron to sell except for delivery well forward, and buyers have to be content with this arrangement, as the supply of hematite from other districts is less than it was before this improvement in demand and in prices set in, several of the furnaces which produced hematite iron now being employed on a commoner description of metal, for which there is also a big demand. Stocks of iron have been reduced, and now stand at 71,955 tons. The movements in stocks are not always to be taken as a guidance to the position of the market, because some of the holders of warrants are large consumers who have covered themselves with supplies of iron in the event of a scarcity in the supply. There are thirty-eight furnaces in blast, and the output of iron is all going into consumption. An improvement is also noticeable in the iron ore trade, the demand being much larger than the supply. Local raisers are quoting 18s. per ton net, f.o.b., for good ordinary qualities, and best sorts are at 22s. Foreign ores are in very full demand, and are selling at 23s. net at West Coast ports.

Steel.

The local steel trades are not in a satisfactory position, as the demand for rails is exceptionally quiet, and the advance in prices has resulted in checking the desire to place certain orders until more favourable terms can be arranged. Heavy sections are now anywhere between £6 10s. and £6 15s. net, f.o.b. West Coast ports. The mills are only partially employed. The demand for shipbuilding material is fairly good, but the orders held are not sufficient to maintain regular activity. Prices have gone up to £7 15s. net cash. Merchant steel is still in slow request. Of course, in the present state of things, it pays smelters better to sell their iron, even if by doing so they keep their steel mills comparatively idle.

Shipbuilding and Engineering.

There is nothing new to report in shipbuilding, which is quiet, but in the engineering trade there is a brisk state of things, except in the marine shops, where good orders recently secured are at a standstill, awaiting alterations in design. An important arbitration case under the Board of Trade was brought to a close last week at Westminster between the Corporation of Barrow and the Furness Railway Company as to the length of dolphins or jetties to be constructed in connection with the new Walney Bridge on each side of the opening span. Sir Benjamin Baker, who designed the bridge, provided for 50ft. dolphins on each side, but the Furness Railway Company asked for jetties on the south side 400ft. long and on the north side 200ft. long. Sir William Matthews is the arbitrator, and will make his award in due course.

Shipping and Coal.

Shipping returns show some improvement this week. The total exports of iron and steel this year so far have reached 774,731 tons, being a decrease of 976 tons on the corresponding period of last year. Coal and coke are dearer. Blast furnace coke is now 26s. 6d. per ton net at West Coast furnaces.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Iron Market: Advances all Round.

THE upward movement in irons has been more marked than ever since last report. At their meeting, last Friday, the Lincolnshire Ironmasters' Association raised their prices by 1s. 6d. per ton, making the official quotations as follows:—Lincolnshire, No. 3 foundry, 52s. 6d. per ton; No. 4 foundry, 60s. 6d. per ton; No. 4 forge, 59s. 6d. per ton; No. 5 forge, mottled, white, and basic, 63s. per ton. Makers are well sold for three months, and are not at all eager for business, there being a very general impression that high-water mark has not yet been reached in iron values. A similar feeling prevails in Derbyshire, where values have risen sharply since last report. Derbyshire No. 3 foundry is now at 64s. per ton, and No. 4 forge at 59s. per ton, these figures showing an advance on the week of 4s. per ton in the first instance and of 2s. per ton in the second. Here, again, makers are in the position that they have their output booked forward, and anticipate that more money will be obtained later on. Bars and sheets maintain the advance noted last week:—Bars, £7 15s. to £8 per ton; sheets, £9 5s. to £9 15s. per ton. In hematites, West Coast and East Coast have gone considerably higher. At the time of writing West Coast are quoted from 89s. to 90s. per ton, less 2½ per cent., delivered at Sheffield and Rotherham; East Coast, 85s. to 86s. per ton net.

The Heavy Industries.

There is no change to report in the various departments of the heavy trades. Manufacturers are generally very busy, the railway material makers being especially well employed, chiefly on foreign and colonial account. Several of the home companies have been placing orders for rolling stock accessories, and the establishments concerned are certain of good work on home and distant account for some time well into the New Year. Steel manufacturers are in receipt of encouraging orders in their leading branches of production. Steel for railway material is in excellent request, and likely to be still more heavily called for in the New Year. The better classes of tool steel continue to be in satisfactory demand, and the high-speed steel, which has formed so prominent a feature of the industry this year, fully maintains the brisk condition already reported.

Coal Trade with Hull.

South Yorkshire and adjoining collieries continue to do a remarkable business with Hull. The return for November of the Hull Incorporated Chamber of Commerce and Shipping discloses figures which show a trade considerably beyond that previously attained in the eleventh month of the year. The tonnage received at the great Yorkshire port already exceeds the former largest year—1900—the weight for the eleven months ended November 30th last having been 4,650,400 tons, compared with 3,457,616 tons last year, and 3,864,960 tons in 1900, when, by the way, steam coal for locomotive purposes fetched the highest price recorded—16s. per ton. The quantity taken to Hull during November was 492,224 tons, being an increase of 160,624 tons on November of 1905. Exports again exhibit a striking advance, the weights forwarded to foreign markets, 223,537 tons, comparing with 141,277 tons for November of 1905. For the eleven months the weight shipped from Hull was 2,300,747 tons, showing an increase of 751,334 tons over the tonnage for the similar period of 1905. The coastwise trade has also been greatly augmented, the tonnage up to November 30th being 714,264 tons, or about double what was done during the whole of last year.

House and other Coal.

Reports vary considerably as to the house pits in this and adjoining districts. A sharp touch of frost caused a stimulus to business as long as it lasted, but the hard weather was soon followed by milder conditions, with rain, and activity was thus short-lived. But there has been a considerable increase in the demand. Recently the house coal pits have only been working moderate time, a condition of affairs partly contributed to by shortage of wagons. The production of smalls has thus been much reduced, making all kinds of manufacturing fuel very firm. For next year's contracts, 6d. per ton advance over the figures obtained a year ago is being offered, but the coalowners require a shilling more. Prices of house coal are unchanged.

Coke, &c.

In coke, slack, and smudge the activity already reported is fully maintained. In slack and smudge good samples fetch 4s. 9d. per ton, and manufacturing fuel, for use in Lancashire and Yorkshire mills, remains at about 3s. 6d. to 3s. 9d. per ton. The values of coke are rising, the requirements of the principal smelting districts being increasingly heavy. Unwashed coke is now quoted at from 12s. 9d. to 13s. 9d., washed coke from 14s. to 15s. per ton.

Yorkshire Miners and Conciliation.

The Council of the Yorkshire Miners' Association held a special meeting at Barnsley on the 8th inst. to consider the situation arising out of the amended wages scheme which the deliberations in London had brought forth. The proposals commence with a 5 per cent. advance from the first making-up day in January—an additional 2½ per cent. having been conceded since the original scheme was propounded—together with a minimum rate of 37½ per cent. and a maximum of 60 per cent. above the 1888 rate, the new Conciliation Board to exist for three years. The details having been fully explained and discussed, the Council passed a resolution expressing the opinion "that the best interests of the men in Yorkshire and the Miners' Federation of Great Britain will be served by accepting the offers made in London this week, with any further alteration in working that the Conciliation Board can arrive at, and the delegates present at this meeting strongly recommend the same to our men."

Foreign Trade in Cutlery.

There is a steady improvement in the requirements of foreign markets, but the advance in business is not so great as could be wished. For November the exports of cutlery reached a value of £65,966, which compares with £62,978 and £58,042 for the corresponding months of 1905 and 1904. For the eleven completed months of the year the value is £651,342, which compares with £609,064 and £631,683 for the similar periods of 1905 and 1904. On the month the increasing markets are Sweden, Germany, Netherlands, Belgium, Spain and Canaries, United States, Chili, Brazil, Argentine Republic, Australia, New Zealand, and Canada. Decreases were shown by Russia, Norway, France, Cuba, British South Africa, and British East Indies. The largest increase was shown by Brazil — from £3213 for November, 1905, to £4870 last month; the largest decrease was with British South Africa, where the cutlery trade with this country fell to £4761 last month from £8810 in November a year ago. The decrease on the eleven months with South Africa, however, was not proportionately so great—the value for the completed period of this year being £47,586, compared with £49,550 for the eleven months of last year. Australia has been our best customer for cutlery, taking up to November 30th a value of £100,420, against £89,888 for the corresponding period of last year. The United States came next with a value of £83,762, against £72,335 for the eleven months of last year. The United States demand is chiefly in the higher grades of cutlery.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Trade Situation.

ALMOST everything in the iron and allied industries is on the up grade; the position is undoubtedly most satisfactory, and there is justification for the general opinion that there will be a continuation next year of healthy trade. The improvement is gathering strength steadily, though this is a period of the year when generally a lull is experienced in business and prices rather tend to weakness. Seldom has there been so much trade activity at this season of the year as is reported at the present time, and this is accepted as a good augury for the course of business next year. There is an upward movement in the demand for and prices of all metals, and this is helping on the return of full confidence in the iron and steel trades. In every branch of these latter industries prices have been raised this month, after, in a number of cases, standing stationary for more than a year.

Clevelan i Ironstone.

One of the great difficulties which the Cleveland pig iron makers have had to encounter of late has been the shortness in the supply of Cleveland ironstone, and but for that, the output of Cleveland pig iron would have been increased substantially. Notwithstanding the activity of trade, the production of Cleveland pig iron this year will probably not exceed that of last year by more than 100,000 tons. Ironmasters and others are prospecting for ore in various parts of the district, and are taking the leaner stone which in past years they rejected.

Cleveland Pig Iron.

The producers of Cleveland pig iron are very well supplied with orders for next quarter's execution, and are less eager to sell than the consumers are to buy. There can be no question that the present output is not equal to the requirements, and it is generally expected that next half-year's prices will be in excess of those of the present time. Makers thus do not wish to hamper themselves ahead with a plethora of lower priced contracts. American demands for Cleveland iron, judging from the reports from the United States, are likely to be even better next year than they have been this. Hitherto all the Cleveland iron that has gone has been for consumers whose works are situate not far from the eastern seaboard, but it is stated in American reports that consumers in the middle States, and even in the West, will have to use foreign pig iron, and that means Cleveland iron, because there is no surplus anywhere else, whereas Cleveland has over half-a-million tons in the public warrant stores. This market is depending a good deal on the American market now, and American iron trade reports are diligently studied. Germany is still receiving Cleveland iron freely, but deliveries will fall off when the weather becomes severe on the Continent. The price of No. 3 Cleveland G.M.B. pig iron this week has been mostly at 63s. 9d. per ton, or 15s. 3d. per ton above the price reported in March, which was the lowest of the year. Second hands are quoting fully as much as producers. No. 1 is at 65s. 3d.; No. 4 foundry at 62s. 6d., and No. 4 forge at 61s. 3d. Some No. 4 foundry has been sent into the public warrant stores this week, but of forge the supply is short of the demand.

Hematite Pig Iron.

The dearth of steel-making pig iron is an important feature of the market. Never before has there been such a large production, but it is short of the requirements, and there is no stock in the warrant stores upon which to fall back. Sellers are rushing the price up to some tune, but this they can well do, as they have no stock in second hands or in the warrant stores with which to compete. Less than a month ago mixed numbers of East Coast hematite pig iron could be bought at 70s. 6d. per ton; this week 80s. has become the regular figure. Of this advance, 3s. 6d. has been realised since the middle of last week. Rubio ore is going up as rapidly, for consumers have now to pay at least 23s. 6d. per ton for it, delivered c.i.f. Middlesbrough, against 19s. 4½d. in August, when the lowest price of the year was reported. Medium coke has likewise been advanced to 22s. per ton, delivered at the furnaces here, that representing a rise of 5s. 6d. per ton this year. It is thought there will be something like a coke famine during the forthcoming holidays, and it is not improbable that some of the furnaces will have to be put on slack blast.

Shipments of Pig Iron.

Never in the history of the trade have larger exports of pig iron been reported at this season of the year than are now being recorded, but they can hardly be kept up at this rate when the traffic on the Continent is hampered by the freezing of the rivers and canals over there. It is pretty certain that this will be the best December on record. Up to 12th there had been exported 52,777 tons of pig iron from the Cleveland district, against 50,196 tons last month; 34,578 tons in December, 1905; and 33,895 tons in October, 1904, all to 12th.

Manufactured Iron and Steel.

The wholesale advances made in the prices of manufactured iron and steel last week have led consumers to buy more freely this week, and a good deal of business has been done, partly because it is believed that further advances will shortly be declared. Consumers themselves expected that quotations would have been raised more than they were, but dearer material will necessitate still higher rates for the finished product. Steel ship plates are now at £7 5s.; iron ship plates at £7 10s.; steel ship angles, £6 17s. 6d.; iron ship angles, £7 15s.; iron bars, £7 15s.; steel bars, £7 10s; steel joists, £6 12s. 6d., all less 2½ per cent. f.o.t. Heavy steel rails can be bought at £6 7s. 6d. net f.o.b.

Shipbuilding.

For some time the shipbuilding business has been a rather weak spot in trade, because of the absence of fresh orders, but it can fairly be reported that there is a distinct improvement, and the demand for new tonnage has increased. Satisfactory orders have been booked, and shipowners have ceased to expect that lower prices for new shipping will rule at any early date; on the contrary, they promise to be higher, as the cost of materials increases. The higher prices are rather stimulating than checking demand, and if freights showed any indications of advancing shipowners would have no hesitation about buying new steamers. Most of the shipbuilders are well booked already for next year; indeed, some have work enough booked to keep their yards in full operation during the whole of 1907. The output of shipping this year will be the largest of any year on record. The strike of the platers at the Tees and Hartlepools shipyards is now in its sixth week. The dispute was not settled at last week's conference at Stockton, as it was expected it would be, and another—the fifth—conference took place at the same place on Wednesday this week.

Coal and Coke.

Business in these industries is in a very flourishing condition, and export demands are very large. Consumers are anxious to buy heavily for delivery ahead, as there is little doubt that they will have to pay more if they wait. The North-Eastern Railway Company, which buys over half a million tons per annum of locomotive coal, has had to pay the colliery owners 1s. 6d. per ton more for its coal for delivery in 1907 than it had to give for 1906. There is a shortage in the supply of coke, and sellers of coke are taking full advantage of this by putting up the price of medium coke to 22s. per ton delivered at the Middlesbrough furnaces, as against 16s. 6d. in June. The export demand this year for Durham coke, and also coking coal, has been quite unprecedented, and this makes it difficult to get adequate supplies for the blast furnaces at home.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Foreign Demand for Iron.

Towards the end of last week the receipt of weaker advices from America arrested the strong upward movement of prices in the iron market, and much of the advance that has taken place in warrants in the course of the week was lost. The continued inquiry for iron early in the present week, together with better reports from America and the favourable Board of Trade returns, wiped out the reaction in prices with which the past week closed. The position continued strong. No doubt there will be fluctuations in warrant prices due to the condition of the speculative account; but the large amount of iron on order is likely to keep the position of the makers strong for some time to come. As to pig iron freights, it may be of interest to note that 7s. 3d. per ton has been arranged from the Clyde to New Orleans, 6s. 3d. having been done from Grangemouth to New York. There are very pressing demands for Scotch pig iron from English consumers.

Scotch Makers' Prices.

There has been a further general advance in the prices of Scotch makers' pig, some special brands being up several shillings a ton. G.M.B., No. 1, is quoted at Glasgow 71s.; No. 3, 69s.; Govan and Monkland, Nos. 1, 72s; Nos. 3, 69s. 6d.; Carnbroe, No. 1, 74s.; No. 3, 70s.; Clyde, No. 1, 74s. 6d.; No. 3, 78s. 6d.; Gartsherrie and Calder, Nos. 1, 75s.; Nos. 3, 71s.; Summerlee, No. 1, 77s. 6d.; No. 3, 72s. 6d.; Langloan, No. 1, 78s.; No. 3, 73s.; Coltness, No. 1, 85s.; No. 3, 72s. 6d.; Glengarnock, at Ardrossan, No. 1, 75s.; No. 3, 70s.; Eglinton, at Ardrossan or Troon, No. 1, 72s.; No. 3, 69s.; Dalmellington, at Ayr, No. 1, 74s.; No. 3, 69s.; Shotts, at Leith, No. 1, 75s.; No. 3, 71s.; Carron, at Grangemouth, No. 1, 77s.; No. 3, 72s. per ton.

The Warrant Market

The warrant market was strong at the opening this week, but afterwards there was less inquiry, with a somewhat unsettled feeling. Cleveland warrants have been done from 63s. 4½d. to 62s. 10d. cash, 63s. 9d. to 63s. 4d. one month, and 64s. 3d. to 64s. for delivery in three months. Cumberland hematite warrants have been done from 79s. to 78s. 3d. one month, 78s. 6d cash, and 79s. to 79s. 3d. three months. Scotch warrants are nominally 67s., while standard foundry iron—various kinds—has been at 62s. 9d. to 62s. 3d. per ton.

Hematite Iron and Steel.

The makers of hematite are paying high prices for ore, the best quality of which is now quoted 24s per ton, delivered on the Clyde. Demand for pig iron has improved considerably on foreign account, and somewhat larger supplies are also required by home consumers. Scotch hematite is quoted 80s. per ton for delivery at the West of Scotland steel works. It has been difficult to bring up the prices of steel to such an extent as to compensate makers for the higher prices they have to pay for the raw material.

Finished Iron.

The makers of finished iron are generally well supplied with work, which will keep them employed until after the turn of

the year. It is stated that as regards new business there is not at the moment a great deal of pressure, and this is confirmed by the statement that recent advances in price have only partially been obtained.

The Coal Trade.

There has been an active business this week in the coal trade. Household qualities have been in extra demand, in consequence of the colder weather. The past week's shipments of coal from Scottish ports are 16,000 tons less than in the preceding week, but they still show an increase of nearly 20,000 tons, compared with the quantity despatched in the corresponding week of last year. The manufacturing demand is active, and prices are generally firm.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

State of the Coal Trade.

ON 'Change, Cardiff, this week, it was reported that the coal market, thanks to arrivals having increased, has been showing a better tendency. With the approach of the Christmas holidays stems are rapidly filling up, and there is every indication of a busy time up to the holidays. There is a good inquiry for best Cardiffs and best Monmouthshire; and several collieries cannot quote for anything like prompt shipment. This is always a good augury. Small coals are steady. Cardiff shipped last week 336,952 tons of coal, 3457 tons of coke, and 8622 tons of patent fuel. Principal ports: River Plate 11 cargoes, totalling 40,000 tons; Genoa 7, 25,000; Port Said 3, 17,500 tons; Newport shipped 76,602 tons of coal, 266 coke, and 3345 patent fuel. Principal destinations: Algiers coal, Vera Cruz patent fuel. Swansea shipped 39,455 coal, 9637 patent fuel, principally Bay of Biscay and North French ports; Venice, Caligari, and Genoa for patent fuel. Port Talbot sent away 28,000 tons of coal, and 4403 patent fuel.

Latest Quotations.

On 'Change, Cardiff, the following were given out as the market prices:—Best steam coal, 15s. 6d. to 16s. 3d.; best seconds, 15s. to 15s. 6d.; seconds, 14s. 6d. to 14s. 9d.; dry, 14s. 6d. to 15s.; best washed nuts, 12s. 6d. to 13s.; seconds, 11s. 6d. to 12s.; peas, 11s. 6d. to 11s. 9d.; seconds, 10s. 6d. to 10s. 9d.; best small steam, 9s. 9d. to 10s. 3d.; best ordinaries, 8s. 9d. to 9s. 6d.; seconds, 7s. 6d. to 7s. 9d.; inferiors, 6s. 6d. to 7s. Monmouthshire semi-bituminous: Best large, 14s. 6d. to 14s. 9d.; best ordinaries, 14s. to 14s. 6d.; seconds, 12s. 9d. to 13s. 6d.; inferiors, 12s. 6d. House coal: Best, 16s. to 16s. 6d.; best ordinaries, 13s. 6d. to 14s. 6d.; seconds, 11s. to 13s.; No. 3 Rhondda, 16s.; brush, 13s. 3d.; smalls, 11s. to 11s. 3d.; No. 2 Rhondda, 12s. 3d. to 12s. 7½d.; through, 9s. 6d. to 10s.; smalls, 7s. 6d. to 8s. Coke: furnace, 17s. to 18s.; foundry, 22s. to 23s.; special foundry, 28s. Pitwood, 22s. 6d. to 24s. Thirty-six large coal steamers were cleared from Cardiff on Monday.

Anthracite.

At Swansea this week, while stating that there was no change in price or condition, it was admitted that the market was firm, and the inquiry well maintained. A steady business is also being done in steam and house coals, and more would be doing in patent fuel but for irregular tonnages. Latest figures are:—Best malting, anthracite, 20s. to 21s. 6d.; seconds, 16s. 6d. to 17s. 6d.; big vein, 15s. 6d. to 16s. 3d.; red vein, 11s. 6d. to 12s. 6d.; cobbles, 18s. 6d. to 19s. 6d.; nuts, 23s. to 24s.; German nuts, 22s. to 23s.; peas, 14s. to 14s. 6d.; rubbly culm, 6s.; duff, 5s. to 5s. 3d. Steam coal is at 15s. 9d. to 16s. 6d.; No. 3 Rhondda, 15s. 6d. to 16s. 6d. Patent fuel, 13s. to 13s. 6d.

Iron and Steel.

A tolerable amount of business is being done at the chief works, but the activity is not general. On 'Change, Cardiff, this week it was stated "that local works were fully supplied with orders, and that prices were firm with a decidedly upward tendency. Prices: Heavy steel rails, £6 10s.; light, £6 17s. 6d. to £7." The chief shipments of the week have been 1600 tons of rails to Kurachie, with 76 tons of fish-plates from Cardiff; and 500 tons of rails from Newport to Liverpool. Pig iron has been coming in from Boston, Lincs, and Whitehaven to Swansea, and from Barrow and Harrington to Newport. The current statement that America is so pressed for home needs as to be unable to export remains unverified, 2100 tons steel bars having come to Newport last week from New York, and 2014 tons from Antwerp. Large quantities of ore continue to arrive for the leading works. Last week Cardiff imported 27,000 tons, Newport 12,000 tons, and Swansea 2000 tons—a very hopeful fact Swansea also imported 1400 tons of iron pyrites, and 1170 tons of blende. At the Metal Exchange, Swansea, this week, quotations were as follows:—Bessemer mixed numbers, 78s. 4d., an advance of 2s. 1d.; Middlesbrough, 62s. 10d., instead of 62s. 6d.; Scotch, 67s., instead of 66s. 6d.; Welsh hematites is at 85d. Steel bars: Siemens, £5 15s.; Bessemer, £6 to £6 2s. 6d. Newport and Cardiff quotations for iron ore are: Rubio, 21s. 6d. to 22s.; Tafna, 22s. 6d. to 23s.; Almeria, 21s. to 21s. 6d. Other Swansea quotations this week are: Block tin, £196 15s.; lead, £19 11s. 3d.; copper, £104 15s.; silver, 32½d. per oz.; spelter, £27 15s. Block tin has advanced 5s.; lead is easier; copper has again advanced; spelter easier; silver advanced. In the Swansea valley spelter is active; nickel silver is becoming a leading industry.

The Tin-plate Trade.

I am glad to note that there are now strong indications of a return of the Russian trade. Information discussed freely at Swansea is to the effect that the machinery and plant working the oil wells in the Baku district is being gradually replaced. Authorities state that up to March, 1905, Russia was taking from Wales 2500 tons of tin-plates per month. This healthy condition was then affected by the mad onslaught upon the wells, and about the middle of last summer the trade was at an end. Since the reign of disorder has practically died out business has begun again, and is now being done to the extent of 1000 tons per month. Indications are now tolerably good that 1907 will witness a complete return of the trade. This is a subject of marked satisfaction in the whole of the tin-plate districts, and, taken in conjunction with improved foreign requirements generally, the prospects of the New Year are promising. I see, by market returns, that there was a record condition at the mills, and at present black plates are in strong demand, with a fair quantity of ternes. Prices are advancing in sympathy with steel; quotations this week vary from 15s. 3d. to 15s. 6d. for ordinary plates. Latest quotations offered are as follows:—Ordinary tin-plates I.C 20 by 14 by 112 sheets, 15s. Bessemer; Siemens, 15s. 1½d. C.A. roofing sheets, £11 10s. to £11 15s. per ton; finished black plates, £11 5s. per ton. Big sheets for galvanising not quoted. Steel bars short in supply.

Newport, Mon., and Electrical Requirements.

The Corporation discussed this week the probable requirements of the Alexandra Docks and Railway, the Electricity Committee having submitted a full report on the matter. The supply was so large that it was estimated that it would be necessary for the Corporation to expend between £30,000 and £40,000 upon plant. The requirement will be, it is expected, between two and three million units of power for working the docks and its extensions. In the end a committee was empowered to make all necessary arrangements to supply the power, if the details of the contract were deemed satisfactory.

NOTES FROM GERMANY.

(From our own Correspondent.)

The Iron and Steel Trade in Silesia.

THE healthy and improving condition of previous weeks continues in all departments. Activity is strong both at the blast furnace works and in the finished iron industries, and quotations remain exceedingly stiff. It is a pity that some works are still engaged in the execution of orders that had been booked previously, when lower prices were ruling. Dealers are deriving a profit from this, for they have secured supplies at comparatively low quotations, which they sell now at the present high prices.

The Rhenish-Westphalian Iron Industry.

Excellent employment prevails in all branches of the iron and steel trade. The demand for semi-finished steel is uncommonly strong, and the mills are often unable to satisfy their customers. The majority of inland consumers are reported to have placed their entire requirements for the first quarter, and also for a part of the second quarter in the next year. The business done on foreign account is very firm, and as all the reports that come in from foreign markets are favourable, an abatement in the export trade is not likely to take place for some time to come. The bar mills are well supplied with work till into the second quarter of next year; the same is the case with the plate mills, most of them being provided with orders for five to seven months. At the hardware factories active employment is reported to prevail.

List Prices.

Pig Iron: Spiegeleisen, M. 92 to 93; good forge quality, M. 78; basic, M. 74 to 75; hematite, M. 85; foundry pig No. 1, M 81; No. 3. M. 78; scrap iron, M. 62 to M. 74, according to quality; old iron rails, M. 93 to 94. Semi-finished steel: Raw bars, M. 97·50; billets, M. 110; plates, M. 112·50 in basic, while for Siemens-Martin quality, M 5 p.t. more is realised; girders, M. 132·50 to M. 135; bars in basic, M. 150 to 155; good merchant bars, M. 165; rivet iron, M. 175; hoops, M. 157·50 to 160; drawn wire, M. 162·50 to 167·50; wire rods, M. 145; common plates, M. 150 to 152; boiler plates, M. 165 to 170; sheets, M. 165, all per ton free at works.

Coal in Germany.

Consumption in engine fuel continues to be higher than production in Silesia, and it is only on account of a comparatively limited demand for house fuel that serious difficulties have been prevented hitherto, for deliveries in coal are generally insufficient, and there is still a scarcity of wagons. All sorts of coke meet with vigorous demand, although prices are steadily advancing. The Union of Cologne Coal Dealers is reported to have resolved upon a rise in prices for at least some sorts of coal from April 1st next year.

Pig Iron Scarce in Austria.

The Wittkowitz Ironworks consuming a great part of its make in pig iron, only small lots have been thrown on the market, and the scarcity in crude is the cause of general complaints. Foundry pig iron is often realising 50 heller p.q. more than what is officially quoted because supplies are so small. The mild weather has favoured the building trades, and a lively inquiry is still coming in for bars and sectional iron; plates also sell freely. Scrap iron is scarce at present. In the Austro-Hungarian coal industry a slight abatement in demand has been noticed during the past week; still a regular trade has been done on the whole, and prices are stiff. Exports to Germany remain lively.

Satisfactory Condition in Belgium.

The tone all round is very animated and firm both in the pig iron industry and in the various branches of the manufactured iron trade, and there was even an upward tendency perceptible in a few instances. Orders in finished iron come in very freely, and good employment is secured to the works for the first two quarters in 1907. Bars for export quote 160f. p.t. f.o.b. Antwerp, and higher prices have now and then been realised. Steel bars vary between 162·50f. and 167·50f. p.t. Inland quotations are exceedingly stiff, in consequence of the lively demand prevailing. In girders, plates, and drawn wire an excellent trade is done at very firm prices. Exports in girders for transmarine requirements have been satisfactory, but not so extensive as to justify a rise in prices. In rails a marked improvement can be reported, both locally and on foreign account. According to the *Cour de Bourse*, negotiations are being carried on between the Sambre and Mosel Works, Ougrée, Couillet, and Cockerill, for the purpose of forming a new syndicate for semi-finished steel. The business in all sorts of fuel is healthy, and the production of small coal goes into immediate consumption. If frost sets in, as to all appearance it will now, the prices for house fuel are likely to meet with an immediate advance. Coke is exceedingly well inquired for, and numerous contracts have been available in spite of the recent advance of 2f. p.t.

The French Iron Trade.

Manufacturers of iron and steel are doing a very satisfactory business, and fresh orders can only be accepted at advanced prices. From the French coal market good accounts are also given, all descriptions of engine fuel meeting with very strong request, and the demand for house coal is improving.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, November 23th.

ORDERS are pending to-day for some 75,000 tons of steel rails, and it is expected that the buyers will be accommodated, although they may be obliged to wait until next midsummer for delivery. During the past week orders were placed at Chicago for 35,000 tons of structural material for delivery during the first half of next year, all of it for local use in Chicago. The orders for iron and steel plates for boiler making, car use, and other purposes are heavy, and there is a large amount of business awaiting acceptance this week, which may not be accepted for some time to come. The scarcity of scrap iron has become very pronounced, and consumers are looking abroad for relief. The advance last week was 3·50 dols. per ton. This sudden advance was due to the purchase by the Carnegie Steel Company of 10,000 tons.

The importation of pig iron during this year will amount to 750,000 tons, which, added to domestic production, will make the consumption not less than 27,000,000 tons. Sales of Bessemer pig have been closed in Western Pennsylvania at 22·50 dols., which shows the condition of the market. The Carnegie Company this week accepted orders for 30,000 tons of steel rails, of which 13,000 are for a Kansas electric line. Light steel rails have been advanced 1 dol. per ton.

Our Geological Survey has been looking carefully into the prospective supply of coal within the territory of the United States. Their investigations afford a good deal of satisfaction in showing that the deposits are very extensive, and that the possibility of exhaustion for ages to come may be practically dismissed.

Urgent inquiries are being made for basic iron, and negotiations are being hurried along for English and Scotch irons, and some very heavy deliveries will be made during the winter months. Mills are for the most part very meagrely supplied with iron at present, although most of them have contracts for delivery, which will supply all ordinary needs.

The demand for copper from European sources has increased within the past few days, and prices have advanced about twenty points. Casting grades have also gone up, and 22 cents has been asked. The imports at Atlantic ports since November 1st have been 2661 tons of refined copper, and 11,169 tons of ores. There has been a sharp advance in tin, due possibly to the purchase of 450 tons of spot tin by the Steel Corporation; the market is a little unsettled, and prices will continue to fluctuate. Lead is in moderate demand at 5·90.

NEW YORK, December 5th.

The greatest activity of the year in sheet iron now prevails, and contracts have been placed during the past few days for the delivery of light and heavy sheets during the coming six months, much of it being intended for May and June deliveries. There is also a very active demand at present for material for pipe lines and for boiler tubes, some of the larger concerns having decided to place their contracts for the coming year at this time, where they find manufacturers willing to contract so far ahead. Like activity prevails in nearly all of the bar mills of the country, and this activity may be attributable to the advances which have been made, and which portend still further advances within the next sixty days. Very few contracts have been placed for a week in steel rails. About two-thirds of the capacity for 1907 have already been placed, and the rail makers are showing an unwillingness to accept more business at present. Their unwillingness, however, is overcome, and a great deal of new work is now about to be placed. The trolley line promoters and builders are placing, or are about to place, some very heavy orders for rails for electric roads, and the pressure from this source may be very heavy during the winter.

About 200,000 tons of foreign iron have already been contracted for to be delivered during the coming few months, of which about 25 per cent. is iron for steel making. About one-half will come from the Middlesbrough region. It is expected that the bulk of this material will be loaded within the next sixty days. A quantity is intended for delivery at interior points. Speculators are taking a hand in the game. Alabama iron has been advanced 50 cents per ton within a week, and No. 2 is now selling at a minimum of 19 dols.; some contracts have been placed as high as 19·50 dols. The makers of basic pig continue to book large orders, and are willing to take every order that comes along, provided they can have their own time for delivery. Most of the large buyers of basic pig are in Eastern Pennsylvania. The business in scrap iron during the past week for delivery in Eastern Pennsylvania totals 20,000 tons, nearly all heavy steel melting scrap. The business in steel rails and structural material has been rather light, while the pressure upon the steel plate makers continues heavy, and will probably continue to tax the producing capacity of the plate mills throughout the entire coming year. The consumers of both iron and steel are extremely anxious to contract for supplies as fast as orders are received.

Electrolitic copper has sold as high as 22¾ cents for export. Our reports show that the consumption of copper in Europe has increased 32 per cent., and this fact, taken in connection with the heavy increase in consumption on this side, points to a continued advance in prices. The exports of copper during November were about 18,000 tons. Tin is dull and unsettled, November deliveries amounting to 3150 tons. Lead is inactive at present, and is selling at about the same prices. Refined spelter has advanced slightly.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE firm of **A. Borsig**, Berlin, has had two "Grand Prix" awarded it for its locomotives at the Milan Exhibition.

FRASER AND CHALMERS, Limited, have entered into arrangements with Mr. Victor H. Coates to continue the manufacture of the engines as made by his late firm.

MR. FRANK ROBINSON, of the United States Steel Products Export Company, has been appointed sole agent in the Midlands for the Ebbw Vale Steel, Iron and Coal Company, Limited, succeeding Colonel Alexander McBean, who has represented the company for many years and has now resigned that position.

LAUNCHES AND TRIAL TRIPS.

HENRIK IBSEN, cargo steamer; built by Sir Raylton Dixon and Co., Limited; to the order of Herr V. Torkildsen, Bergen; dimensions, 396ft., 52ft. 8½in., by 28ft. 4in.; engines, triple-expansion, 25in., 41in., 67in. by 45in., pressure 180 lb.; constructed by North-Eastern Marine Engineering Company, Limited; launch, October 18th.

ROBERTO NUNEZ, steel screw tug; built by Messrs. Lobnitz and Co.; to the order of Messrs. S. Pearson and Son; dimensions, 100ft. by 20ft. by 12ft.; engines, triple-expansion, 13in., 22in., and 35in. by 27in., pressure 160 lb.; constructed by builders; the vessel averaged over 10½ knots; trial trip, November 1st.

DIRPHYS, steel screw steamer; built by Wm. Gray and Co., Limited; to the order of the Navigation à Vapeur Panhellenique, Athens; dimensions, 342ft., 47ft. 6in. by 22ft. 6in.; engines, triple-expansion, 24in., 38in., 64in. by 42in., pressure 180 lb.; constructed by the builders; an average speed of 11 knots was attained; trial trip, November 12th.

TITAN, twin-screw cargo steamer; built by David and William Henderson and Co.; to the order of the Ocean Steamship Company, Limited; dimensions, 500ft., 58ft. by 42ft. 6in.; engines, triple-expansion, 23in., 38½in., 65in. by 48in., pressure 190 lb.; constructed by builders; a mean speed of nearly 16 knots was maintained; trial trip, November 13th.

SIERRA LEONE, steel screw passenger steamer; built by Messrs. Harland and Wolff; to the order of African Steamship Company; dimensions, 370ft., 49ft., and 4000 tons gross; engines, triple-expansion; launch, November 15th.

UTGARD, steamer; built by Northumberland Shipbuilding Company, Limited; to the order of a German firm; dimensions, 372ft., 48ft. by 30ft. 10in.; to carry 7300 tons deadweight; engines, triple-expansion, 25in., 41in., 69in. by 48in., pressure 180 lb.; constructed by Richardsons, Westgarth and Co.; launch, November 15th.

CONTRACTS.—The Athens and Piræus Tramway Company have entered into a contract with Bruce Peebles and Co., Limited, for the electrification and reconstruction of the Athens tramways, including the supply and equipment of 100 cars, and the overhead equipment and track construction for a total length of 60 miles. The French Municipality of Shanghai has given an order to the same firm for ten miles of electric tramway, including thirty cars, &c. &c.—Crompton and Co., Limited, have secured the contract from the Sudan Government for the complete electrical lighting and power installation required for Port Sudan, to the specification of the consulting engineer, Mr. A. G. Marshall, 66, Victoria-street, S.W.—The St. Pancras Ironwork Company, Limited, has carried out for the Underground Electric Railways Company of London, Limited, the contract for spiral staircases which have been fixed at all the stations on the following tube railways:—Baker-street and Waterloo; Great Northern, Piccadilly, and Brompton; Charing Cross, Euston, and Hampstead. There are upwards of forty stations. The staircases are about 18ft. diameter, and vary from 50ft. to 200ft. in height, according to the position of the stations.—Messrs. Joseph Evans and Sons, Culwell Works, Wolverhampton, have appointed Mr. J. M. Gibbons, of Oxton, Birkenhead, as their representative for the Lancashire and North Staffordshire district, for the sale of their steam, electric, and other pumping machinery.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS,** *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

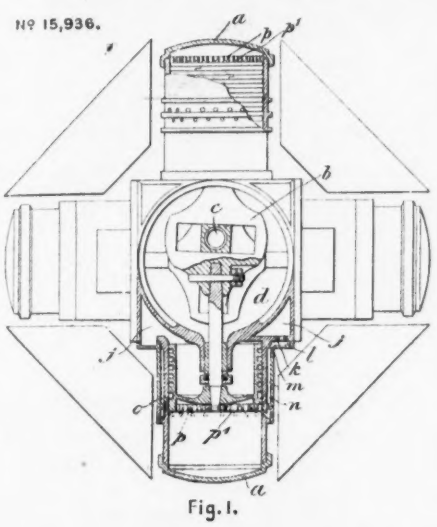
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

INTERNAL COMBUSTION ENGINES.

15,936. August 3rd, 1905.—AN IMPROVED ROTARY INTERNAL COMBUSTION ENGINE, Alexander Lehmann, 9, Birnam-road, London, N.

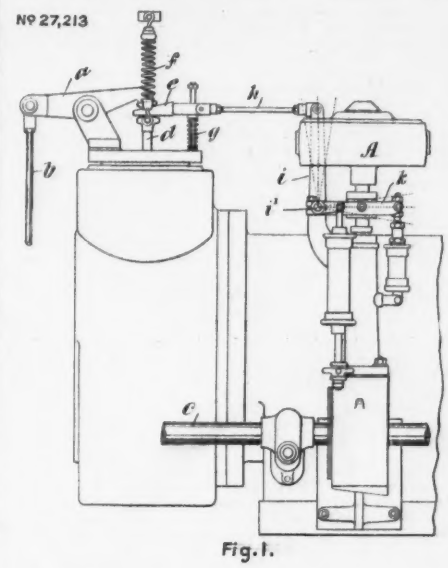
This invention relates to internal combustion engines of the rotating cylinder type, and has for its general object to provide an engine of simple construction which shall be efficient in operation. There are two figures. Fig. 1 represents a side elevation, partly in section, of the motor. The cylinders *a* are arranged in pairs, the one of the pair being oppositely disposed in axial alignment with the other, and the rods of their respective pistons coupled to the same crosshead, so that their pistons always move in the same direction. Two pairs of cylinders are employed, all arranged in the same plane, and the respective crossheads of the respective pairs engage with the same crank pin *c*, so that the engine will have no dead point and shall have as many impulses at each revolution as there are cylinders. The crank pin *c* rotates within an oil bath *d* integral with and constituted centrally between the respective cylinders *a*, separated from the interior of the latter by means of an annular partition provided with bearings and a stuffing-box for the support of the piston-rods, the chamber *d* being filled with oil so as to ensure the perfect lubrication of the crank pin *c* and of the crossheads which work thereon. A square die block is provided within which the crank pin is held to slide in the crosshead. The stationary crank shaft at one end is



hollowed out for serving as an admission passage for the vapour and air, from which it passes through ports into compression spaces *j* provided within the crank chamber casing, which spaces are separated from the crank chamber *d* by means of the wall. From the compression chamber *j* the vapour and air pass through apertures or holes *k* into an annular chamber *l*, and thence through ports or passages *m* into the annular space *n*, whence they pass into the cylinder through the inlet ports *o* on these ports being uncovered by the engine piston. The inlet ports are provided as a series which are disposed opposite to recesses *p* formed on vertical faces p^1, provided around the edge of the top of the piston, so that when the piston reaches its lowermost position the vapour and air are guided to pass in an axial direction parallel to the cylinder wall, thus more effectually ensuring the scavenging of the cylinder of the products of combustion. During the outward stroke of the piston the explosive charge is drawn into the inner end of the working cylinder, wherein it is compressed during the next inward stroke. As the piston approaches the end of its inward stroke the compressed charge is allowed to pass by way of the admission ports from the inner to the outer side of the piston, where it displaces the residual gases from the last explosion, expelling these through the exhaust ports, which are opened just before and closed just after the admission ports. During the next outward stroke the explosive charge thus admitted to the explosion chamber of the working cylinder is further and finally compressed therein, and is ignited at the conclusion of the outward stroke to effect the working stroke.—*November 14th*, 1906.

27,213. December 30th, 1905.—IMPROVEMENTS IN OR CONNECTED WITH INTERNAL EXPLOSION ENGINES, Alfred R. Bellamy, Fordsberg, Edgeley, Stockport.

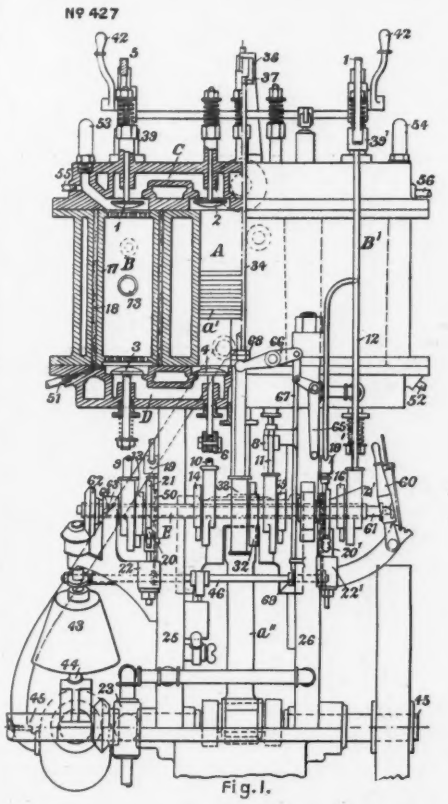
This invention relates to means for varying the lift of the valve admitting explosive mixture to the cylinder. There are two figures. Fig. 1 shows the invention in side elevation. A pivoted lever *a* is oscillated by a connecting-rod *b* and crank through the medium of a cam on the side shaft *c* or other revolving part of the engine. The method of actuating the lever *a* through the rod *b* from the side shaft *c* of the engine is not shown, and may be of any usual or known construction. Between the free end of this pivoted lever *a* and the stem *d* of the valve admitting explosive mixture to the engine is disposed a wedge-shaped or inclined block *e* interposed in such a manner that the pivoted lever acting on the wedge-shaped block brings the face of the same into contact with the stem of the mixture valve, thus opening the valve against the action of the spring *f* on each oscillation of the lever *a*. A compression spring *g* is employed to maintain the wedge or inclined block *e* always in contact with the lever *a*. The inclined block *e* is pivoted to a spindle or rod *h* connected to a lever *i*. This lever *i* is secured to a rod i^1 mounted in suitable bearings. To the rod i^1 are also connected levers *k k*, which are actuated by the governor A of the engine. The oscillating movement of the levers *i k*, indicated by dotted centre lines, in answer to the calls of the governor thereon, reciprocates the rod *h* and causes the wedge-shaped block *e* to be correspondingly moved laterally between the end of the pivoted lever *a* and the stem *d* of the mixture valve. When the load on the engine is light the levers *i k* move the thinner end of the wedge *e* above the point of the stem *d* of the mixture valve, leaving a gap between the wedge and the valve stem. The pivoted lever *a* therefore oscillates the wedge *e* some little distance before the inclined wedge can come into contact with the valve stem *d*, and the mixture valve is opened to its smallest extent. This opening of the mixture valve is gradually increased to a maximum as the governor slides the inclined wedge until the thickest part of the wedge comes into contact with the valve stem. When the wedge *e* is pulled right away from between the valve stem and the oscillating lever, as would happen if the engine



"raced" or "ran away," the lever *a* would be incapable of opening the mixture valve at all, thus cutting off admission entirely of explosive mixture to the engine.—*November 14th*, 1906.

427. January 6th, 1906.—IMPROVEMENTS IN HEAT ENGINES, *Simon Lake, 23, Friedrich Wilhelmstrasse, Berlin, Germany.*

There are nine figures. Fig. 1 is a side elevation of the engine showing one of the combustion chambers or furnaces in section. The cylinder is also shown partly in section. The engine comprises a single cylinder A fitted with the usual piston a^1 and connecting rod a^{11}; joined to this cylinder are two combustion chambers called furnaces B B1. These furnaces are connected with the cylinder at both the top and bottom of same by valve-fitted passages C D, the upper passages C being for the purpose of admitting the contents of the furnace to the cylinder above the piston, while the lower passage D admits the air drawn into the cylinder below the piston on its up-stroke through valves. These passages are closed by valves 1 2 3 4, as shown in the sectional view; the furnace not shown in the section is a duplicate. Valves 1 and 4 are controlled by the levers 5 6, and the corresponding valves in the other furnace by levers 7 and 8 respectively, which levers are operated by the connecting-rods 9 10 11 12 and their

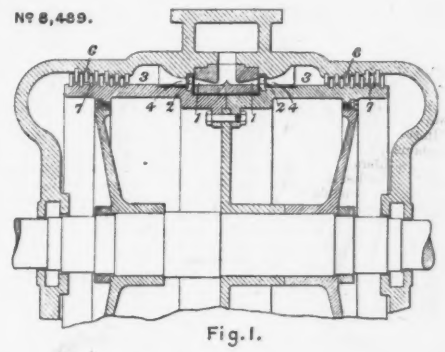


reciprocating yokes, and the cams 13 14 15 16 on the cam shaft E, which is driven at half the speed of the main shaft by bevel gears in a customary manner. The furnaces are provided with a refractory lining 17, which may also be insulated by asbestos or other suitable substances 18 to prevent the heat of the same from being too rapidly absorbed by the water contained in the surrounding water jacket. The fuel pumps 19 19^1 are operated by levers 20 20^1 and cams 21 21^1, the fuel being forced into the cylinder by the action of a spring in the housings 22 22^1. This spring is of sufficient power to inject the feed at the maximum pressure at which the engine is designed to operate. The pump injects the fuel through the pipe directly into the furnace and with considerable force, depending on the power of the spring. A force pump 23 is operated by the excentric 24. This pump discharges into the bottom of the hollow columns 25 26. The water then passes into the lower cylinder and furnace cover, then up through a pipe to the upper cylinder cover, and from there into a steam-and-water reservoir with regulator. Connected with this reservoir at its lower end is a pipe leading the water to a circulating pump run from the main shaft by bevel gearing, from which pump it is forced around the cylinder and furnace walls and finally back again to the reservoir through the pipe shown broken off. The exhaust is controlled by the double cam 32, yoke 33, and connecting-rod and lever 36. This cam is so set as to open valve 37 on each up stroke of the piston. Steam admission valves are shown at 39 and 39^1 with automatic cut-off detent, stroke-regulating link and starting lever 42 and 42^1; 43 is a governor which may be of the usual centrifugal type mounted on the gear shaft 44. This gear shaft is provided with bevel gear connecting the main crank shaft 45 with the half-speed shaft E. The governor controls the amount of fuel fed by the pumps through the medium of the shaft 46, the arm, the stud, and the cams 50; 51 and 52 show small pipes broken off which lead into the furnace chamber. These pipes are for the purpose of injecting a small quantity of steam or water which acts as a scavenger to clean and slightly cool the temperature of the furnace, which might be desirable with certain kinds of fuel. 53 and 54 are relief valves; 55 and 56 are pipes fitted with stop valves led to the air reservoir; 60 is the engine reversing lever connected with a rod 61 extending through the hollow cam shaft E to the bevel wheel 62. This bevel gear is carried in the bearing 63 by an extension of its hub shown by dotted lines. This hub contains a helical slot through which a pin is fitted extending into the shifting rod 61. This rod is provided with a feather which allows it to be moved endwise only in its relation to the cam shaft. The position of the bevel gear in its relation to the cam shaft is controlled by the pin 64 in the helical slot. The lever 65, the rocking arm 66, and the rod 67 open up the exhaust valve by engaging the stop 68 on the exhaust operating rod 34. At the same time the rod 67 engages a toe 69 on the shaft 46, cutting off the fuel supply when desired. The cylinder is jacketed by asbestos or other non-conducting material and covered with a casing. There is also a spraying plug. 73 is a raised seating on the walls of the furnace for spraying the fuel as it is injected under pressure. This sparking device is so formed as to distribute the injected fuel to all parts of the furnace.—*November 7th*, 1906.

TURBINES.

8489. April 9th, 1906.—IMPROVEMENTS IN ELASTIC FLUID PRESSURE TURBINES, *Raymond N. Ehrhart, 7712, Edgerton-street, Pittsburg, Pennsylvania, U.S.A.—Date under International Convention, April 12th*, 1905.

This invention relates to elastic fluid pressure turbines of the kind in which the velocity energy of the motive fluid in passing from one stage to the next succeeding stage is re-converted into pressure energy. It is well known that in turbines where the velocity energy of the motive fluid issuing from the several stages is re-converted into pressure the turbines have not been efficient in the intermediate and low-pressure stages. The object of this invention is to combine with an efficient high-pressure section utilising the re-conversion principle a low-pressure section of impulse and reaction blading of the Parsons type. There are two figures. Fig. 1 is a broken longitudinal section. The steam or other motive fluid is expanded in nozzles 1 down to the exhaust pressure. A fraction of the velocity energy due to the nozzle expansion is absorbed in a single row of impulse blades 2. The



steam on leaving the impulse blades 2 collects in a transforming receiving chamber 3. The inlet 4 of the receiving chamber 3 is provided with guide vanes which prevent rotation of the steam issuing from the impulse blades 2. The transforming receiving chamber 3 is so proportioned that the velocity energy of the steam is re-transformed into pressure energy. The steam passes from the transforming chamber 3 to the exhaust chamber 8 through a final section of alternating annular rows of stationary guide vanes 6 and moving blades 7, whereby the steam is fractionally expanded down to the exhaust pressure, the expansion occurring both between the rows of vanes 6 and between the blades 7. Between the transforming receiving chamber 3 and the final section of impulse and reaction blading, a section may be interposed in which a portion of the thermal energy of the re-converted fluid is transformed into kinetic energy in the form of velocity, and either wholly absorbed in a single row of impulse blades or fractionally abstracted in a plurality of rows of rotating impulse blades provided with suitable intermediate guide vanes.—*November 14th*, 1906.

SUBMARINES.

8131. April 4th, 1906.—APPARATUS FOR TAKING OBSERVATIONS FROM A SUBMARINE VESSEL, *Simon Lake, Universitäts-Strasse, 3 B, Berlin, Germany.*

This invention relates primarily to a construction of periscope or omniscope for carrying into effect an improved method of taking observations from a submarine vessel, the method consisting in the execution of the three following known operations:—Bringing the vessel to a predetermined depth of submergence; training a rotatable sighting instrument on a target or object irrespective of the course being pursued by the object under observation; and instantaneously elevating and lowering the instrument. There are four figures. Fig. 1 shows in vertical section the conning tower and part of a submarine boat equipped with a periscope embodying these improvements, the conning tower being submerged whilst observations are being taken through the periscope, the sighting-tube of which is elevated above the surface of the water. A is a sighting tube, the upper lenses of which are above the surface of the water. This tube A is provided with the usual lenses, and is of uniform diameter, and is fitted with a rounded or conical cap at the top, the construction being such that the tube will readily pass through the stuffing-box C. This stuffing-box is fitted with packing rings of any well-known construction, which serve to prevent water from penetrating into the interior of the boat. G is a hydraulic cylinder with a pipe g^1 leading to the elevating cylinder B. H is an air cylinder, the piston of which is connected to the piston of the hydraulic cylinder G by means of a common piston-rod. The air supply is received from an air reservoir H^1 which may be at any convenient part of the boat. The stuffing-box and guide piece C is provided at its upper end with a flap valve M, which valve is normally held to its seat by a coil spring. The boat is running along with the observing instrument above the surface. The enemy is sighted, and it is desired to withdraw the instrument entirely below the surface of the water, so as to

prevent any wake or disturbance of the water which would betray the presence of the submarine. The handle controlling the valve F is now turned to the proper position, and air is admitted into the end of the air cylinder H next to the hydraulic cylinder G, and the hydraulic piston, shown in dotted lines, is caused to travel to the opposite end of the cylinder G which withdraws the hydraulic fluid from beneath the piston, and tends to create a vacuum below the piston, so that the sighting tube is consequently withdrawn into the lower position, whereupon the valve M immediately closes and seals the upper end of the guide piece C. The direction of the enemy having been first ascertained, the submarine may now be put on a course designed to intercept the enemy, still maintaining the same depth of submergence. It is now possible to take instant observations from time to time without exposing anything above the surface except for a brief moment. When it is desired to take an observation, the instrument is first pointed in the direction in which the enemy is known to be. The observer puts his eye to the eye-piece, and turns the handle of the valve F, whereupon a stroke of the air piston in the cylinder H acting through the medium of the hydraulic fluid passing through the pipe g^1 shoots the observing instrument above the surface again, and the opening in the tube A is brought opposite the eye-piece so that vision is secured. A turn of the valve F again withdraws the instrument. From experiments it is found practical to take an observation during the brief interval of one second.—*November 14th*, 1906.

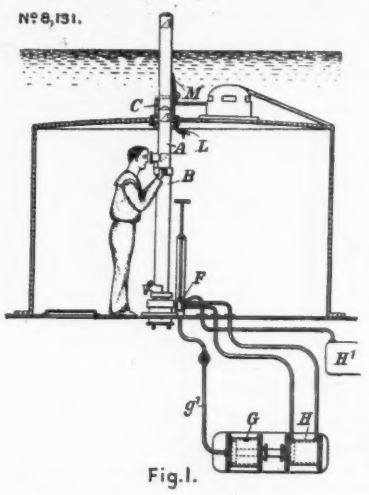


Fig. 1.

LOCOMOTIVES.

7813. March 31st, 1906.—IMPROVEMENTS IN AND CONNECTED WITH LOCOMOTIVE BOILERS, *Ernst Deffner, 23, Karlortstrasse, Dusseldorf, Germany, and the Deutsch-Oesterreichische Mannesmannroehren-Werke, Dusseldorf, Germany.*

This invention relates to locomotive boilers, and more particularly to the type of locomotive boiler having a water-tube fire-box. In order to reduce the height of a boiler of this type, it has already been proposed to dispense with the steam receiver above the multitubular boiler, and to connect the header, or upper drum, of the water-tube fire-box with the boiler shell at the rear fire-tube plate. In such an arrangement, if the normal diameter of boiler shell is retained, the header occupies so much space in the tube plate as to considerably reduce the space available for fire tubes, thus reducing the heating surface of the boiler. The object of this invention is to enable the header of the fire-box to be connected with the tube plate of the boiler shell in such a manner as to increase instead of diminish the heating surface, and so as to only very slightly add to the weight of the boiler, and without unfavourably affecting the distribution of the same. There are five figures. Fig. 2 is a longitudinal sectional elevation of one form of boiler. In carrying out the invention according to one mode, the last ring or belt R of plating of the boiler shell is made conical, so that a rear tube plate R^1 of increased diameter is obtained. Into the upper part of this plate the single header V of a water-tube fire-box is connected by riveting. This header or drum acts as a steam collector in continuation of the steam space in the shell, which is increased owing to the conical form of the end portion of the shell. It may be still further increased by making more than one belt conical. The water tubes of the fire-box are expanded into the header in the usual way, and so arranged that they leave sufficient space in the rear tube plate of the boiler shell for the necessary number of fire tubes. It has been found by trial that as many as forty-nine more fire tubes can be inserted in this manner, thus considerably increasing the heating surface, in addition to the whole heating surface of the fire-box being increased, due to the larger tube plate.—*November 14th*, 1906.

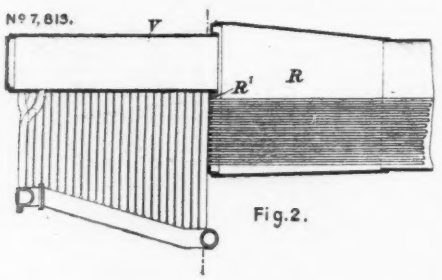


Fig. 2.

ROAD MOTOR VEHICLES.

19,902A. October 2nd, 1905.—IMPROVEMENTS IN IRREVERSIBLE CONTROLLING APPARATUS, *Charles A. Arbey, Besançon, Doubs, France.*

This invention relates to mechanism designed to be mounted on the steering-rod of a motor car for the purpose of controlling the brake, ignition apparatus accelerator, speed gear or the like, in such a manner that the control is irreversible. The invention involves an application of the known principle of coupling two shafts or rotatable members by means of a helical spring or by two oppositely-acting springs, which is or are caused by radial expansion, to make contact with the internal wall of a hollow cylinder for the purpose of acting as a friction clutch or locking device. There are five figures. Fig. 1 is a vertical section of the controlling mechanism. *a* is a friction cylinder fixed to a non-rotatable tube *g* forming part of the steering gear of a motor car. Into this cylinder the elastic helix *b* is "sprung," the end b^1 of this helix or spring being fixed to the rod or shaft *c* to be rotated. The end b^2 of the spring engages a slot provided in the boss of the handle *d*, the latter being connected with the rod *c* in such a manner that a certain amount of relative rotational movement is allowed to the two parts. The abutment surfaces with which the boss is provided are adapted to co-operate with abutment surfaces of a projection formed on the rod. Rotation of the handle in one direction causes the grip of the spring *b* on the cylinder *a* to be loosened before the rod *c* is acted on by means of the respective abutment surfaces. Rotation of the handle *d* in the opposite direction causes the abutment surface of the boss to come into contact with the abutment surface of the rod, the latter being thereupon so rotated that a pull is exerted on the end b^1 of the spring, and the grip of the spring is thus loosened. The mechanism controlled by the rod *c* tends to impart rotation to the latter. A force acting on the rod for this purpose causes a thrust to be exerted on the end b^1 of the spring, and the latter is thus expanded and prevents the movement being transmitted.—*November 14th*, 1906.

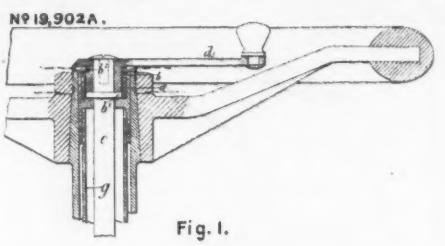


Fig. 1.

MISCELLANEOUS.

23,187. November 11th. 1905.—AN IMPROVED FLEXIBLE SHAFT COUPLING, John Fielding, Sherborne House, Gloucester.

This invention relates to an improved construction of flexible coupling for connecting two shafts together. The improved coupling consists of two separate bosses or hubs, secured to the adjacent ends of the two shafts. These bosses have arms similar to those of a wheel or pulley. The arms of one boss interlace between those of the other, each set leaning towards the centre line dividing the two shafts and bosses, so that the outer ends of the two sets of arms have a common centre line. A flat flexible belt connects the outer ends of the two sets of arms. There are two figures. Fig. 1 shows the improved coupling in which the two parts A B are connected together by a belt of any flexible material of suitable strength.—*November 14th*, 1906.

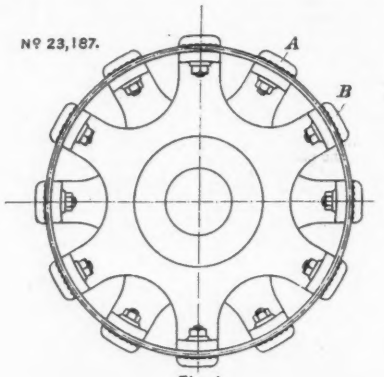


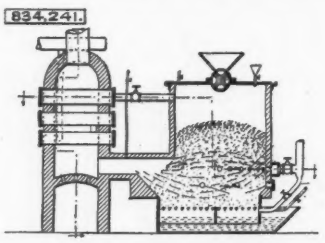
Fig. 1.

SELECTED AMERICAN PATENTS.

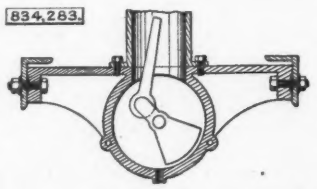
From the United States Patent-office Official Gazette.

834,241.—PROCESS OF MANUFACTURING ILLUMINATING GAS, *W. H. Adams and F. Powell, Portland, Oreg., assignors of twenty-five one-hundredths to said Adams, fifteen one-hundredths to said Powell, and sixty one-hundredths to The Ladd Metals Company, a corporation of Oregon.—Filed July 16th*, 1904.

This invention consists in establishing a horizontal zone of combustion in a long horizontal body of fuel, and a zone of distillation above the zone of combustion, the products of the two zones being removed separately, the outflow of the distillation products being regulated in accordance with the colour of the two products when burned. There are two claims.



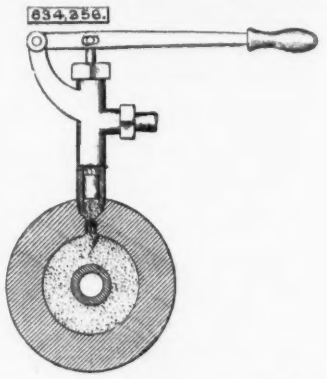
834,283.—MOTOR VEHICLE, *M. Fischer, Zurich, Switzerland.—Filed March 1st*, 1906.



This invention consists in the combination with a vehicle frame of an engine casing having two lateral arms, stirrups adjustably secured in the vehicle frame, and adapted at first to embrace loosely the arms of the engine casing to permit of the latter being swung around its horizontal axis for adjustment in proper position relatively to the gearing, and after the adjustment to be tightened so as to secure the motor casing to the vehicle frame. There are two claims.

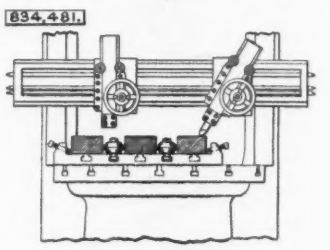
834,356.—CYLINDER FOR TREATING HEATED METAL, *G. H. Benjamin, New York, N.Y., assignor to the Coe Brass Manufacturing Company, a corporation of Connecticut.—Filed May 19th*, 1905.

This is a curious invention. It consists in forcing sand into a mould in such a way as to put pressure on the ingot or tube billet to augment its density and secure solidity. There are eleven claims of "the-house-that-Jack-built" type.



834,481.—WORK-HOLDER FOR MACHINE TOOLS. *C. C. M. Mortensen, Schenectady, N.Y., assignor to General Electric Company, a corporation of New York.—Filed April 11th*, 1904.

On the bed of a planing machine are fixed thick hard steel discs with sharp edges. The work to be planed is forced against these discs by inclined setting screws, as shown. There are six claims.



NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made at the Admiralty:—

Engineer Commanders.—H. Hawkins, reappointed to Orion, for Malta Royal Naval Reserve, and to assist Engineer-Captain of Malta Reserve, on recommissioning; C. J. Huddy, to the Glory, and W. C. Stevens, to the President, as engineer overseer at Messrs. Vickers, Son, and Maxim's Works; John E. Johnson, to Irresistible, on recommissioning; A. T. H. Stone, to the Topaze; and H. T. Knapman, to the Adventure; C. W. Bolt, to the Sirius; W. A. J. Davies, to the Assistance; John W. Agnew—lent—and Frederick J. Flood, both to Victory, additional, for oil fuel course.

Engineer-Lieutenants.—Roland C. Miller, reappointed to Orion, for service with the Engineer Commander for charge of machinery and for Malta Royal Naval Reserve, on recommissioning; Thomas J. Wells, reappointed to Orion, additional, for Malta Royal Naval Reserve, and for training of stokers, on recommissioning; Edwin F. St. John, reappointed to Orion, additional for supervision of boats; William F. Pepperell, reappointed to Orion, additional for charge of stores and care of workshops, machinery, on recommissioning; and Wellesley J. Steil, to Vulcan, additional, for the Stag, vice Mowlam; G. Wormald, to the Sapphire, for the Swale; W. C. S. P. Bartwell, to the Proserpine; C. Barker and A. Turner, to the Bacchante; E. Cole, to the Leviathan; A. C. Turnbull and S. Brown, to the Bacchante, and the Leviathan; H. W. Harris, to the Terpsichore, on recommissioning, temporary; James Maxwell and Arthur W. J. Turner, both to Irresistible, on recommissioning; D. E. Duke, to the Topaze; W. S. Reid, to the Adventure; W. Dawson, to the Assistance; H. J. Loveridge, to the President, temporary, to assist Engineer Overseer at Messrs. Parsons, Wallsend-on-Tyne; J. Legate to the Hecla for the Surly; T. B. Huddy, to the King Edward VII. for duty with Engineer Captain of Atlantic Fleet in connection with use of oil fuel and bituminous coal; Elias G. Pallot, Frederick W. Sydenham, Harry V. Gordon, and William J. Ford, all to Victory, additional, for oil fuel course (lent); and Arthur N. Dupen, to Victory, additional, for oil fuel course.

Engineer Sub-Lieutenants.—S. C. Whyham, to the Bacchante; Russell O. L. Bond, to Irresistible, on recommissioning; Macleod G. A. Edwards, to King Alfred.

Artificer Engineers.—Peter E. Gregory and Albert J. Day, both to Irresistible, on recommissioning.

THE JUNIOR INSTITUTION OF ENGINEERS.—On Friday evening, 30th November, through facilities granted by Mr. Jas. R. Chapman, the chief engineer of the Underground Electric Railways Company of London, a party approaching two hundred in number paid a visit of inspection to the company's Great Northern Brompton and Piccadilly Railway. Starting from Piccadilly-circus Station, they were taken by train to the extreme west end of the line at Hammersmith, the working being explained *en route*. On returning some alighted Hyde Park-corner Station to see the special signalling arrangements there, whilst the others proceeded to Covent Garden, where similar apparatus is installed. The whole party, on arriving at Holborn, walked along the tube of the Strand Extension Works and saw the Greathead shield in operation at the working face. Entering the train again, they went on to Holloway-road Station, and examined with much interest the double spiral continuous electric moving track, which is to travel at 100ft. per minute, and take passengers up and down simultaneously, and is being fitted in lieu of the lifts. The electrically-driven pumping plant at Finsbury Park Station was the last item in a long evening's programme. Here four hydraulic lifts are used, each working by three rams with a water pressure of 700 lb. per square inch. Before the party dispersed Mr. Geo. H. Hughes, vice-chairman of the Institution, expressed the members' acknowledgment of all that had been done to render the occasion so interesting.

LATEST GREAT NORTHERN ENGINES.

No. III.

By CHARLES ROUS-MARTEN.

IN THE ENGINEER of March 30th and April 6th I described the newest locomotives designed and built by Mr. H. A. Ivatt for the express services of the Great Northern Railway, and gave many specimens of the excellent work they are performing in their regular daily course. It may be remembered that one class—which also consists of only one engine—was not represented in my notes so far as work went. That was No. 1300, which is a *quasi* de Glehn four-cylinder compound built by the Vulcan Company, of Newton, Lancashire, this particular locomotive being "in hospital" at the time my Great Northern observations were made.

Let me briefly repeat that Mr. Ivatt's "Atlantic" or 4-4-2 class engines may be divided into six sub-classes:—(1) The "990" set, viz., Nos. 250, 252-260, 949, 950, and 982-990, 21 in all, which have boilers of moderate size giving 1444 square feet of heating surface; (2) the "251" lot, viz., Nos. 251, 272-291, 295-301, and 1400-1420, 50 in all, which are identical save in having far larger boilers, 5ft. 6in. in diameter, with 2500 square feet of heating surface; (3) No. 271, which has nearly the same boiler as the "990" class, with 1808 square feet of heating surface, but which has four cylinders—two inside and two outside—each 15in. by 20in., instead of a single pair 18½in. by 24in., driving the four-coupled wheels; (4) No. 292, a four-cylinder balanced compound of Mr. Ivatt's own design; (5) No. 294, which is identical with No. 251, save in having 25 lb. more steam pressure, viz., 200 lb. instead of 175 lb.; (6) No. 1300 above mentioned. All have four-coupled wheels, nominally 6ft. 6in. in diameter, but 6ft. 7in. to 6ft. 8in. with new tires. I gave an account of the work done by engines of each of these classes, excepting only No. 1300. I have now to relate my experiences with her.

Through the courtesy of the Great Northern locomotive authorities No. 1300 was specially detailed to take the 1.30 p.m. Leeds fast express from King's Cross, which is regarded as "the hardest train to work on the whole Great Northern system," owing to the combination of speed and weight involved. In this instance, as on the previous occasions, the load behind the tender was approximately 300 tons. It must be confessed that the performance of No. 1300 differed in no material degree from those which I have already recorded to the credit of the other Great Northern "Atlantics," compound or non-compound. After a single slip at the start, No. 1300—very well and carefully driven by Barker—attacked the rise of 1 in 105 through the Maiden-lane tunnel, which comes almost before the tail of a long train is clear of King's Cross platform, in excellent style, quickly attaining 20 miles an hour, and then, up the subsequent rise at 1 in 110 through the Copenhagen tunnel, 26 miles an hour. The speed increased to 60 at Hornsey, near the point where the 8¼ mile constant rise at 1 in 200 begins. As the bank was mounted the speed gradually declined until it had dropped to 52·8 at Southgate, 50 at Oakleigh Park, 48·9 at Barnet, and, finally, to 47·9 in the South Mimms tunnel, which rate was then maintained to the summit at Potter's Bar Station. A fast downhill run to Hatfield should have followed, but at Redhall box, 16 miles from London, signals were against us, and we were slowed to a walk for a whole minute. This cost us fully four minutes' delay, from which we did not recover until we had breasted the next summit at Woolmer Green. Then, however, the engine was allowed to run with full freedom, and some capital work was done. After passing Stevenage the speed rapidly rose from 69·2 to 77·4 miles an hour, and then to 80·3 miles an hour at Hitchin, finally reaching 81·8 at Biggleswade, which station was passed in 6 min. 39 sec. from Hitchin, distance nine miles, thus averaging 81·1 miles an hour, a remarkably smart achievement, accomplished without the engine being at all exceptionally extended. At this point, however, the interest of the run ceased, for it was found that the big end of one low-pressure piston-rod was hot, and so the train was brought to a standstill at Sandy, having run the 12 miles from passing Hitchin to the Sandy stop in 9 min. 39 sec. No doubt thus exists as to the swiftness of the locomotive, and it was made clear by that single experiment that if some compounds on other lines be sluggish, at any rate Great Northern No. 1300 is not. That such a reproach does not attach to No. 292 either, Mr. Ivatt's own compound, my notes, previously published, have made sufficiently clear.

Several journeys with the non-compound "Atlantics" gave interesting results. No. 278 on the day Scotch express, weighing 290 tons behind the tender, got through Potter's Bar in 17 min. 32 sec., the minimum rate up the 8¼ miles of 1 in 200 being a fraction under 50 miles an hour. Hitchin was passed in 35 min. 29 sec. from King's Cross, and a speed of 80 miles an hour was attained near Arlesey. At Everton box we had to slow down to five miles an hour for permanent way repairs, the slack being maintained as far as Tempsford. Huntingdon was passed in 61 min. 1 sec. from London, Peterborough—dead slow—in 78 min. 31 sec. for the 76½ miles from King's Cross. After recovering speed we maintained a rate of 60 miles an hour until close to Essendine; then it began gradually to fall off up the long ascent at 1 in 264, 1 in 200, and 1 in 178 respectively. At Bytham we were still doing 55, but just before passing Corby our rate dropped for no apparent reason to 45 miles an hour. Up the final three miles at 1 in 178, however, to the Stoke summit we steadily recovered, until at the top we were going at 49·5, with still a tendency to accelerate. After a long slow into Grantham we arrived there in 114 min. 23 sec. from London, or in 111½ minutes net. No. 280, of the same class, took us on from Grantham to York. As the time allowance was very liberal and the load well within the engine's powers, the driver took things very easily throughout. We passed Newark in 16 min. 43 sec. from the Grantham start, Retford in 37 min. 58 sec., Doncaster in 56 min. 40 sec., and after a stop of 70 seconds for signals, outside Selby, we finally reached York 2 minutes before time, having run the 82¾ miles from Grantham in 95½ minutes exactly. The lowest points touched up the 1 in 200 to Askham tunnel and the 1 in 198 to Piper's Wood were respectively 49·8 and 45 miles an hour. But the engine, as I have said, was going under very easy steam, there being no object in hurrying.

Returning from York by the corresponding train with a load of 245 tons behind the tender, we had No. 1337 as our engine, one of the "1321" 4-4-0 class, with inside cylinders 17½in. by 26in., four-coupled wheels 6ft. 7in. in diameter, and leading bogie. This engine accomplished what appeared to me a very smart performance from York to Grantham, the run being done in 90 min. 50 sec., or in 6 min. 10 sec. under booked time. Doncaster was passed in 39 min. 51 sec. from York, Retford in 18 min. 25 sec. from Doncaster, Newark in 19 min. 14 sec. from Retford, Grantham in 17 min. 30 sec. from Newark. The lowest uphill speeds were 42·8 up the 1 in 178 to Askham, and 45 miles an hour approaching Grantham, the train being before time. No. 1337, well as she did, could certainly have improved upon these times. From Grantham the train was taken by No. 283, of the 4-4-2 "Atlantic" class, which throughout the whole run to London had to fulfil the always tiresome task of "killing time." Notwithstanding that we were stopped by signal for 2 min. 2 sec. at the Paxton box, and badly slowed at Everton, while all the way from Hitchin we had to run under easy steam, we, nevertheless, reached King's Cross 7 minutes in front of booked time. The train, I may observe, was the first part of the up-day Scotch express.

All these performances went to show that Mr. Ivatt's new engines of each class have a great deal "in hand" on present booked times, even with modern loads.

Although the bulk of the Great Northern express work is now performed by the splendid "Atlantics," No. 251 and her sisters, Mr. Ivatt's very fine single-wheelers are still entrusted with many important trains, and so far as my experience has gone they never fail to perform quite satisfactorily the duties entrusted to them. Even when put upon the Leeds and Scotch expresses, whose loads are considerable, the 7ft. 6in. single-wheelers rarely, if ever, fail to keep good time. Of course their absolutely ideal work is the running of such trains as the non-stopping expresses between King's Cross and Sheffield, which as a rule consist only of three or four twelve-wheelers, one being a diner, but which are booked to cover the 161¾ miles from King's Cross to Sheffield in 2 h. 50 min., thus averaging 57 miles an hour from start to stop, notwithstanding bad "service slacks," *e.g.*, to 10 miles an hour past Peterborough, and to even less round the excessively sharp curve at Retford which leads to the Great Central line, while thenceforward there is a frequent liability to checks at Great Central boxes. No. 100 of this type on the 6.10 p.m. from King's Cross passed Potters Bar (12¾ miles) in 15 min. 56 sec.; Hatfield (17¾ miles) in 20 min. 34 sec.; Welwyn (22 miles) in 24 min. 6 sec.; Hitchin (32 miles) in 33 min. 8 sec.; Huntingdon (58 miles) was passed in 56 min. 45 sec. from the start, and the sixty-second milepost was breasted in exactly one hour from King's Cross. At Yaxley (72¼ miles) we had run from London in 69 min. 34 sec., consequently thenceforward we had to slow down all the way to Peterborough in order not to be too much in advance of booked time. As it was, we passed through Peterborough Station at a slow walking pace in 74 min. 14 sec. from London, having dropped fully 1 min. in slowing from Yaxley. After clearing Peterborough our speed soon rose again, and it had reached 61 miles an hour when we passed Tallington, and 67 miles an hour at Essendine. Up the bank to Stoke we fell off a little, and were only going at 45 miles an hour at the summit. Our time past Grantham (105½ miles) was 106 min. 24 sec. from London, 32 min. 10 sec. from Peterborough; Retford (138¼ miles) was reached in 139 min. 13 sec. from King's Cross. After rounding the curve on to the Great Central at little more than a walking pace we travelled forward very easily, ultimately reaching Sheffield in 2 h. 49 min. 3 sec. from King's Cross—a very smart performance, which, nevertheless, could have been materially bettered by the engine had this been necessary or desirable. But the train was well up to time, and any earlier arrival would simply have meant our being blocked outside Sheffield.

These specimens of actual work done will be accepted as showing that Mr. Ivatt has designed and constructed for the Great Northern Railway several classes of locomotives which have proved themselves thoroughly well suited to the work they are required to perform, and which do perform that work in an entirely efficient and satisfactory manner.

THE WALLACE ALCOHOL CALORIMETER.

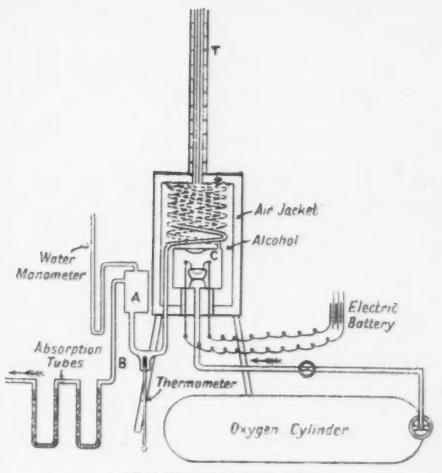
A CALORIMETER for the testing of coal, in which alcohol is used as the heat-measuring liquid, has been devised by Professor Wallace, of the School of Mines, Kimberley. We understand that so far only the instrument constructed by Professor Wallace himself has been constructed, and we have not had an opportunity of testing it, but it appears to combine great accuracy with ease of manipulation.

A diagrammatic sketch of the instrument appears in Fig. 1. The coal is burned in a small asbestos cup inside the combustion chamber C, which is surrounded by a closed cylindrical chamber containing alcohol. A long glass tube T, of small bore, and attached to a graduated scale, dips into the alcohol and allows of the expansion of the latter when heated by the combustion of the coal. The amount of this expansion is a measure of the heating value of the coal.

During combustion oxygen is supplied continuously from a cylinder at a constant pressure as measured by the small water manometer attached to the top of the discharge cylinder A. The products of combustion reach this cylinder after traversing a long worm tube immersed in the alcohol, and escapes by the tube B, which leads them to absorption tubes if an analysis is required. A thermometer inserted in the tube between the discharge cylinder and calorimeter measures any loss of heat with the discharge.

An air jacket is placed around the alcohol cylinder to prevent excessive radiation, and the coal is fired by raising a piece of platinum wire to incandescence electrically. Small glass windows placed in the top of the different cylinders allow of observations of the combustion of the coal.

It will be seen that the instrument is somewhat similar to Carpenter's calorimeter, but there are important modifications which are essential for the success of the principle introduced by Professor Carpenter. In the first place, the use of alcohol allows an expansion five or



ALCOHOL CALORIMETER

Fig. 1

six times that of water, and this expansion is also, according to Professor Wallace, much more uniform than that of water.

The expansion of water is so peculiar that, without knowing its temperature exactly—and there is no means provided in the Carpenter calorimeter—it is doubtful whether this instrument is any more accurate than the well-known Thomson calorimeter.

It would be of little avail elaborating an instrument so sensitive as this—even the heat of the operators' body will influence the readings—unless, as the inventor points out, somewhat careful attention is paid to the method of use and the condition of operation. If one is aiming at diminishing errors to a small fraction of 1 per cent., the radiation correction must be properly estimated, as it forms by far the most important source of error in this method; the ordinary calorimeter equivalent determinations being unnecessary, as the instrument is calibrated by burning 0·6 gramme of pure carbon at different temperatures. This is necessary, as the expansion of alcohol is not quite constant, but increases with temperature. Calibrating the instrument in this manner, Professor Wallace finds that the points lie almost perfectly on a nice curve, and the almost perfect agreement of values

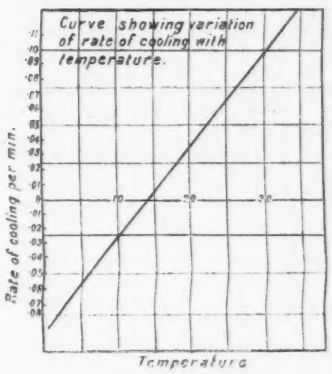


Fig. 2

obtained at any given temperature proves the accuracy of the method.

The following is the method of procedure:—The asbestos cup containing the finely powdered, weighed sample of coal—0·6 to 0·7 of a gramme—is placed in the combustion chamber and the top of the alcohol in the tube adjusted to a convenient reading near the zero of the scale. This reading is taken, and the time noted. Five minutes later the reading is again taken in order to find the rate at which the calorimeter is receiving or losing heat. The oxygen is next turned on to the required pressure—from 2in. to 3in.—and the coal lighted by momentarily connecting the battery circuit; at the same time the reading is noted.

At once the alcohol begins to rise, and one-minute readings are taken until combustion has ceased and all the heat has been given to the alcohol, and further, until the rate of cooling due to the radiation at the maximum temperature has been obtained. As soon as combustion ceases the operator reduces the pressure of oxygen to a

fraction of an inch or so, or just enough slowly to drive the residual hot gases through the worm.

In order to obtain the heat lost by radiation the rate of loss of heat at the lowest and highest temperatures are plotted on a temperature base, and the loss at the intermediate temperatures obtained from this. These losses when added together give the correction to be applied to any temperature on the assumption that the rate of cooling is proportional to the excess of temperature above the temperature of the atmosphere.

As the instrument is its own thermometer the lower reading corresponds to the temperature of the atmosphere.

In the example below the first column gives the time, the second the corresponding readings, the third the sums of these taken two at a time in order to produce the fourth column, indicating the average temperatures during the minute intervals; the fifth column is the radiation loss per minute at each average temperature as taken from the radiation curve; the sixth gives the sums of these from the beginning, and the seventh the corrected temperatures.

As a rule the calorimeter receives heat from the atmosphere at the commencement of the experiment, and consequently the correction is plotted below the abscissæ in the diagram, and is marked negative in the column. It is found advisable to arrange conditions so as to ensure this, as then the total radiation correction is minimised, and the loss due to its estimation incorrectly—it can never be exactly estimated—becomes negligible. A separate room should be used for the calorimeter, and a determination made shortly before noon, when the room is slowly getting warm and the calorimeter following behind.

Method of Estimating Rise of Liquid in Tube.

I. Time.	II. Reading.	III. Sums.	IV. Average readings.	V. Radiation loss per minute.	VI. Total radiation loss from commencement.	VII. Corrected readings.	VIII. Temperature of room.
5 25	1·93						74 deg.
32	2·45						
5 39	2·65	7·05	3·52	− ·069	− ·069	2·65	
40	4·40	14·15	7·07	− ·045	− ·114	3·29	
41	9·75	25·95	12·97	− ·008	− ·122	9·63	
42	16·20	38·20	19·10	+ ·030	− ·092	16·08	
43	22·00	48·60	24·30	+ ·063	− ·029	21·91	
44	26·60	56·80	28·40	+ ·089	+ ·060	26·57	
45	30·20	62·20	31·10	+ ·103	+ ·163	30·26	
46	32·00	64·62	32·31	+ ·113	+ ·276	32·16	
47	32·62	65·48	32·74	+ ·114	+ ·390	32·89	
48	32·86	65·85	32·92	+ ·115	+ ·505	33·49	
49	32·99	66·01	33·00	+ ·116	+ ·621	33·64	
50	33·02	66·03	33·01	+ ·116	+ ·737	33·74	
51	33·01	66·00	33·00	+ ·116	+ ·853	33·84	
52	32·99	65·91	32·95	+ ·115	+ ·968	33·86	
53	32·92	65·76	32·88	+ ·115	+ 1·083	33·92	
54	32·84	65·60	32·80	+ ·114	+ 1·197	33·95	
55	32·76						
56	32·67						
57	32·56						
58	32·45						
59	32·33						
6 0	32·20						
1	32·08						
2	31·97						

The rates of cooling were taken at the beginning from 5.25 until 5.32, which works out − ·074 per minute, and at the end from 5.55 until 6.2, which gives + ·113 per minute. These are plotted, as shown in Fig. 2, on a base corresponding to the average reading from which the figures in the fifth column are obtained.

The coal was lit when the reading was 2·65; hence, 33·95 − 2·65 = 31·30 is the corrected rise of the liquid in the tube.

This rise of 31·30in. for 0·6 gramme corresponds to a rise of 52·16 per gramme. In order to determine the calorific value from this, the graph obtained by burning pure carbon in the instrument at different temperatures must be referred to—Fig. 3. This graph shows the slight

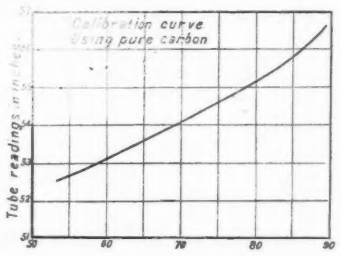


Fig. 3

variation in the expansion of alcohol with temperature; it follows the well-known law with liquids of increasing expansion with temperature. The expansion given by a gramme of carbon at the temperature of the experiment (74 deg.) is 54·5, therefore the calorific power of the coal is $14{,}600 \times \frac{52{\cdot}16}{54{\cdot}50} = 13{,}970$ B.T.U.

It will be observed that with this class of calorimeter the actual amount of liquid in it does not in any way influence the readings, as the smaller the quantity of alcohol the greater will be its temperature, and consequently the actual expansion will be unaffected. This allows the zero of the instrument to be adjusted at pleasure, which becomes necessary from time to time through a little evaporation, and also from the extreme differences in the temperatures of working. A flexible metal disc manipulated by a screw allows of altering the zero, though in the instrument used by Professor Wallace, which was originally built by Messrs. Schaeffer and Budenberg on the Carpenter principle, sufficient latitude is not allowed for this, and on very cold days a little fresh alcohol has to be added through the expansion tube. If any firm takes in hand the manufacture of alcohol calorimeters on this principle, attention must be given to this point, in order to save time and add to the convenience of working.

The alcohol in the tube is very sensitive to changes in temperature, and the operator should not stand near it any longer than is absolutely necessary; and, as has already been mentioned, if possible, determinations should be made in the early part of the day when the calorimeter is slowly receiving heat from the atmosphere, in order to have the working conditions as constant as possible.

Adopting these common-sense precautions, and estimating the radiation losses in the manner shown, an apprentice may be trusted to work this simple instrument and furnish results within 0·3 per cent. of the true calorific value.

Many experiments made by the inventor under very different conditions of temperature, and lasting over a considerable period, show the instrument to be more accurate than the above in the hands of a skilful experimenter. The preliminary standardisation of the instrument by burning pure carbon—prepared from best refined loaf sugar—will show the extraordinary accuracy of the method, as the points fall on a nice curve of the correct shape.

That the calorimeter extracts all the heat from the products of combustion has been proved by the inventor by inserting a thermometer in them, as shown in the sketch. No perceptible rise in temperature is observable when the pressure of the gases in the combustion chamber is regulated to 2in. or 3in. of water. A correction must be applied for the water evaporated during combustion, but there is no nitric acid correction necessary, as the pressure of the oxygen is normal.

The actual amount of carbon-dioxide and other gaseous products of combustion can be measured by absorption tubes placed on the exit cylinder, and the amount by which the heat, calculated on the carbon and sulphur so determined, differs from the actual heat, may be used to calculate the percentage of hydrogen present in the coal.

THE WALSCHAERTS VALVE GEAR.

Among the numerous arrangements that have been schemed and adopted for giving motion to the valve in reversing steam engines probably none has risen so slowly in favour among engineers, and at the same time achieved such a measure of ultimate success, as the Walschaerts valve gear. In the particular branch of locomotive engineering it bids fair to supplant all other types, at any rate, on the Continent, where the merits of this gear and the identical form known as the Heusinger or Waldegg gear are so well recognised that probably 90 per cent. of the present output of locomotives is so fitted.

British engineers have till lately, with characteristic caution, taken it up only to a limited extent at home, although for abroad it has been fitted, of course, whenever so specified in locomotives and marine engines. Mr. B. Malcolm, we believe, was the first to adopt this gear in this country; this was in the eighties on some inside cylinder locomotives for main line traffic on the Belfast and Northern Counties Railway—now in working agreement with the Midland Railway—and so satisfactory has it proved that he has extended the system to compound engines—see our illustration, January 5th, 1900—and has, in fact, adopted it as his standard practice. With outside cylinders the effect of the gear on the external appearance—a point to which much greater attention has always been paid by British than by continental engineers—may have acted as a deterrent. Perhaps the advent of the rail motor coach may have paved the way for it, for with remarkable unanimity nearly all the steam-propelled outside cylinder type, whether built by the railway companies themselves or by private firms, have been so fitted, and Mr. H. A. Ivatt has adopted it in his new class of compound express locomotives for the Great Northern Railway—see our issue for January 26th last. In the United States the past two years have been marked by the great attention that has been paid to the Walschaerts gear, the initiative being due to the American Locomotive Company, which has fitted it to all classes of engines.

From these facts it is evident that the gear must have many good features. What these are may be deduced from a consideration of its mode of action as illustrated by Figs. 2 and 3, page 630, and Fig. 1. It is usually classed with the "radial" gears, in which the motion of the valve is compounded of motions derived from points travelling in curved paths. In the case of the Walschaerts gear one motion is derived from a point in a circular path round the crank shaft; the other from a point in a path as nearly as possible parallel to that of the piston-rod, and derived from a point in it. These two components are impressed on a floating rod or "combining lever," which gives motion to the valve rod. The first component includes a curved link oscillating on its centre, and in which a radius rod can be adjusted to enable the steam to be reversed, and the degree of expansion or cut-off to be altered. The second component derived from the crosshead is reduced in amount by proportioning the combining lever. This component gives the lap, also the lead, which is in consequence invariable, whatever the point of cut-off. The point in the path round the crank shaft differs in phase 90 deg., or nearly so, from the crank, so that the valve is moving fastest just when the crank is passing the dead points, thus giving quick opening and closing. It should be noted that if the forward motion of the engine be taken, as is usual, from the lower end of the link, the excentric point will *lead* the crank for outside admission valves and *follow* the crank for inside admission—*i.e.*, piston-valves. The radius rod for outside admission valves is attached to the combining lever between the valve stem and the crosshead link—see Figs. 2 and 3—while for inside admission valves it is above the valve stem—see Fig. 1. It is obvious that, with so many variables, and with the irregularities inseparable from the conversion of circular into linear motion, the gear is difficult to design correctly, and this may have militated against its introduction. It is not proposed in this article to go into the question of the method of design.[1]

When correctly designed the steam distribution is correct over the whole range of cut-off in backward and forward gear, and in this respect the defects of the link motion at early cut-off is well known. Following out the same comparison, the space on the crank shaft taken up by the excentrics is saved; experience in the States has shown that a reduction in weight of 35 per cent. in the working parts, with a consequent reduction in driving power, can be obtained. The lessening of wear and tear is proved by the longer time the gear remains in good condition before requiring to come into the shops, and disposes of the prediction originally made that the increased number of working parts would make it impracticable. A constructional advantage is that it brings the valve chest readily into a position above the cylinders; this also renders all parts readily accessible for lubrication, a point much appreciated by the driver. The cost of construction appears to be in favour of the link motion.

A glance at the history of the gear will prove interesting[2]; indeed it will surprise most engineers to know how old the Walschaerts gear really is. We are carried back to the days before the link motion had been introduced—in fact to the period of the gab gear, in which alterations in cut-off were well-nigh impracticable and throttling was the only resource of the driver. Many brains were at work upon the problem of a cut-off gear, and an astonishing number were produced and actually tried. Amongst these was that of Henry Cabry, an Englishman who spent a lifetime in the service of the Belgian State Railways and latterly filled the post of Inspector-General. His gear, designed prior to 1842, was a variant on the fork or gab gear. Instead of the forks being on the ends of the excentric-rods the fork was on the lever connected to the valve rod, and as its jaw was parallel for some depth the adjustment of the pin in it permitted a very slight variation in the cut-off.

It was at this juncture that Egide Walschaerts[3] came upon the scene. He was born at Malines on the 21st of January, 1820. The opening of the line between Brussels and Malines in 1835—the first railway in Belgium—and the consequent rise of the latter place as the central point of the Belgium railway system seems to have determined the bent of his strong mechanical genius. Some locomotive and other models made and shown by him at an exhibition at Malines in 1838 attracted the attention of the Minister Rogier, who entered him at the University of Liège, but his studies there were interrupted by a serious illness and were never completed. We hear of him again in 1841 at a National Exhibition at Brussels, where he showed a miniature locomotive and a launch, for which he was awarded a silver medal.

In 1842, in his twenty-second year, Walschaerts entered the workshops of the State Railway, at Malines, as a mechanic. He was made shop foreman at Brussels two years later, and whether it was his lack of a diploma, his dislike of red tape, or his innate modesty, he remained in that position until his retirement, about 1885. However that may be, he took a prominent part for many years in the design of locomotives for the State Railways; many of his ideas were adopted by the Compagnie du Grand Central Belge; the class of goods engines created in 1862 belongs entirely to him. In 1874 he designed a new type of Corliss engine, shown at Paris in 1878 and at Antwerp in 1885, for the manufacture of which he founded works at Brussels which were conducted by his son. He died on the 18th February, 1901, at Saint Gilles, near Brussels, at the ripe age of eighty-one,

1 See Dalby, "Valves and Valve Gears," and a pamphlet by Mr. C. J. Mellin, of the American Locomotive Company.

2 We are indebted to Professor J. Boulvin, of Ghent, for information; *cf.* his article, *Revue de Mécanique*, x., 1902, page 105.

3 The surname is often misspelt as well as mispronounced. The spelling is as given in this article, and the pronunciation is, as nearly as can be represented in print, Wal-skärts.

having lived to see the success of his gear. By those curious in such matters, some analogies between events in his life and those of William Howe, the inventor of the link motion, may be traced.

It was the same year that Walschaerts rose to the position of foreman that saw the birth of his reversing gear. On the 5th October, 1844, a certain F. Fischer, an engineer in Brussels, made an application for a Belgian patent[4], and on November 30th a patent, No. 2382, "Pour une nouveau système de distribution de la vapeur applicable aux machines fixes et locomotives," was granted to him for fifteen years. Fischer took out the patent for Walschaerts, because the latter, on account of his official position, could not exploit it in Belgium. Fischer never afterwards claimed the slightest share in the invention. Had such a claim been advanced it would have been disproved by the fact that on October 25th of the same year Walschaerts in his own person obtained a French patent[5] for fifteen years "Pour des tiroirs de machines à vapeur."

The descriptions and drawings attached to these two specifications are practically identical, and are interesting in showing the first stage in the evolution of the gear. The description shows that the inventor quite realised its properties and recognised its wide applications.

Referring to Fig. 2, page 630, which is taken from the French patent, it will be seen that the motion of the point round the crank shaft is obtained by an excentric, the rod of which is ⊣-shaped, with a pin at either extremity of the crossarm. These pins engage in a link, oscillating symmetrically on a fixed shaft. The reversing lever raises or lowers the excentric rod, and to ensure that only the forward or the backward pin shall be engaged at one time, the central part of the link is enlarged. Thus far the influence of Cabry's gear can be traced. The oscillation of the link varies with the position of the pin in it, and this motion is transmitted by an arm to the combining lever, which has a slot for the fixed point of the crosshead to work in.

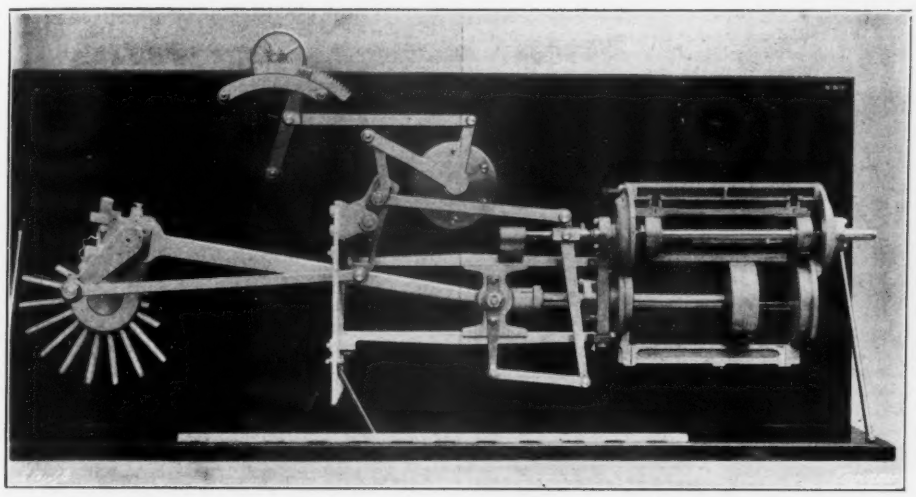


Fig. 1—MODEL OF WALSCHAERT'S VALVE GEAR

At first glance it would appear simpler to have had only one pin on the excentric rod, working in a plain link, but this would have necessitated giving the pin considerable range, consequently introducing a serious error, owing to the virtual change in the angle of advance of the excentric thereby caused. The inventor, by the expedient of two pins and a link, enlarged in the centre, kept this error as small as possible, consistent with giving sufficient motion to the link.

It does not appear that any locomotives were actually fitted with this gear; indeed, in this form it was inferior to the link motion, which, although it can hardly have reached Belgium by this time—only two years after its introduction in England—must have arrived there soon afterwards. It was, in fact, this competitor—more suited to the less exacting environment of that time—which kept Walschaerts in the back ground.

The perfected form of the valve gear with which we are familiar to-day was applied in 1848, as is shown by a drawing still preserved in the shops at Brussels, entitled "Detente variable système E. Walschaerts à appliquer a la locomotive No. 98—Bruxelles, le 2 Septembre, 1848"; from this Fig. 3 is taken. The engine had inside cylinders, 11·8in. diameter by 17·7in. stroke, and judging from the drawing, appears to be the same for which the original gear was schemed. A radius rod, instead of the excentric rod, works in the link, and a drag link is added between the crosshead and the combining lever.

By a remarkable coincidence a gear theoretically identical with Walschaerts' was invented quite independently in 1849 by Edmund H. Heusinger von Waldegg, and patented by him in Prussia the same year; hence in German-speaking countries the gear is usually known by one or both of his surnames. He was at that time engineer-in-chief of the Taunus Railway, and was able to apply his gear in 1850 to an outside-cylinder tank engine with cylinders 7in. diameter by 11in. stroke, which he built to his own designs. In 1851 he modified the details and applied it to an inside-cylinder "Sharp" engine. Our illustration—Fig. 4—shows his original arrangement.[6] As it was an outside-cylinder engine the excentric could be dispensed with altogether and its place taken by a short return crank; this was done, resulting in an elegant arrangement. The design of the link is rather clumsy, however, and a sliding and turning pair, somewhat recalling Walschaerts' first arrangement, is used for the connection of the combining lever to the crosshead. An iron model, to a scale of one-fifth, of the new valve gear was exhibited in 1854 at an industrial exhibition at Munich. For a long time subsequently von Waldegg claimed that he was the inventor, and that Walschaerts had pirated the idea from an engine sold to the Cockerill Company, Seraing. When, as a result of the Vienna Exhibition of 1873, the gear began slowly to make its way in Germany, von Waldegg, not having received any benefit from his invention, determined to apply to the Reunion of German Railways for a premium. In 1875 he wrote to M. Urban, chief of the Grand Central Belge, for a certificate as to its use there. In the correspondence which ensued the latter drew his attention to the documents cited above, and with commendable grace von Waldegg admitted Walschaerts' priority and withdrew his claim.[7]

A modern arrangement of Walschaerts' gear is illustrated by Fig. 1, which is taken from a moving model added some years ago to the engineering collections at South Kensington. This represents a French engine built in 1883 for the French State Railway. The cylinders are outside; 17·3in. diameter by 25·6in. stroke, driving eight-coupled wheels 79½in. diameter; the slide valves are of the piston type.

A new invention may sometimes open out a wide field for subsequent inventors to work in; although this has been the case with Walschaerts, none of the modifications have been of as great merit as the original. For elegance we should mention the motion brought out by Professor A. Stévart, of Liège, in 1868, and applied by him to launch engines where the axes of two cylinders were inclined in planes at right angles to one another, and working the same crank. A motion equivalent to that of the excentric is obtained for one valve from the crosshead of the other cylinder. This motion can also be applied to cylinders in the same plane with cranks at right angles.

For steam tramway locomotives, Mr. J. H. Kitson, in 1879, patented a modification of the gear in which the equivalent of the motion round the crank shaft was obtained from a point in the coupling-rod.

A very ingenious modification was patented in Germany by A. von Borries, and shown at the Paris Exhibition in 1900, applied to a four-cylinder compound with cranks at 180 deg. One excentric only — placed inside—was used for each pair of cylinders, and actuated both links; this was rendered possible by the fact that the outside high-pressure cylinder had piston valves, and the inside low-pressure had slide valves, in the manner explained above. This arrangement is applicable also to the case where the cylinders are tandem.

The most recent modification is that by R. von Helmholtz, who does for the gear what Allen did for the link motion. This result is achieved by connecting the radius rod to the link itself, instead of to the link block. The reversing shaft fulcrum is so located that the locus of the suspension point of the link is an arc of a circle, with its chord perpendicular to the centre line of the radius rod in its mid-position. The proportion between the radius of this arc and the length of the radius rod is the same as that between the distance of the radius rod connection above the link block and the length of the lifting link. The same motion of the valve is obtained as in the ordinary gear. Of course, the straight link is easy to make, and with inside admission valves the link fulcrum can be slightly lowered; it has the disadvantage, however, that so little choice is left in locating the reversing shaft fulcrum, that it is not possible to obtain a position for it in all types of engines.

[4] Catalogue des Brevets d'inventions, 1844 to 1846.
[5] Brevets d'inventions. Descriptions des machines, 2me Serie, tome 1, page 232, and plate LIII.
[6] *Organ für die Fortschritte des Eisenbahnwesens*, 1851, page 121, and 1854, page 90.
[7] "Rapports sur l'Exposition Universelle de Paris en 1878," publiée par la Commission Belge, 1880.

RUSSIAN EXPORTS OF IRON AND STEEL.

THE appearance of Russia as a competitor in international iron and steel markets is an event which, although it has so far excited very little attention, having regard to the extraordinary activity prevailing in the principal countries of production, is deserving of brief consideration at the present time. It is probable that, had it not been for the internal disturbances in Russia which followed the conclusion of the war in the Far East, nothing would have been heard, for a long time to come, at all events, of rivalry on the part of Russian works in countries where British, German, and Belgian firms have been accustomed to meet each other in open contest. As the case stands at present, the export question has become of importance to the producers of iron and steel in Russia, owing to the condition of trade in that country in general. It is not from the iron district of Poland that endeavours are being put forth to develop the export department, but from the large works in the south of Russia, and exclusive of those in the region of the Ural. The condition of the works in all the districts is unsatisfactory, as a consequence of the reduction in the volume and value of the Government orders and the restriction of the inland consumption in general. If there is any difference between the three districts, it is slightly in favour of the southern works, which desire to extend their sphere of activity in external markets. The fact that this idea is being promoted clearly illustrates the internal condition of the country, because several of the works were originally established for the purpose of dealing with Government orders, and as these are now lacking in sufficient quantity to provide employment, the only course to pursue is to seek an outlet elsewhere, or gradually proceed, as in Poland, to the closing of some of the establishments.

A further example of the troubles under which the producers in Russia are labouring at the present time is afforded by the diminishing output of pig iron. In 1904 a record was made by the output of 2,970,000 tons of pig iron throughout the empire, this comparing with 2,930,000 tons in 1900, and 2,700,000 tons in 1899. But in 1905 the total production only amounted to 1,125,000 tons, and the first six months of the current year exhibit a decline over the equivalent period of the preceding year. It is, therefore, under circumstances of a reduced demand and a lower output that the southern works are thinking seriously of the ways and means whereby it might be possible to cultivate the export trade, unless an alteration soon takes place in the condition of the home market. So far, what has been accomplished outside the country has apparently been done tentatively, and the exports relate to various classes of products. In the first place, the Providence Russe secured an order for several thousand tons of rails for the Mecca Railway, in competition with the German Steel Syndicate, several months ago, although the latter obtained a portion of the contract; and the same Russian company was recently awarded in open contest an order for rails to the value of £50,000 for the Roumanian State Railways, this being again in rivalry with German as well as other interests. A footing has also been gained by other Russian works in the supply of joists in Austrian Galicia, and of sheets in Egypt, whilst at the same time the exports of wagons and pig iron have also commenced, several thousand tons of the latter commodity having been sent out of the country in the first half of the present year. Orders for water mains for the Roumanian town of Jassy have been declined owing to the cost of transport, and a refusal has been made in the case of joists for Japan, as a consequence of their being required to be rolled according to English measurement in inches. The most surprising report is, however, that from Ekaterinoslav, namely, that rails and joists have been sold for delivery, f.o.b. at Antwerp, at prices equivalent to from £5 5s. 7d. to £5 14s. 4d. per ton, although Belgian statements merely refer to the question as being in the form of offers.

It is, for the present at all events, quite immaterial whether Russian iron or steel has been offered to or purchased by intermediaries as far west as Antwerp is on the European continent. What is material is the determination of the southern works in Russia to promote the export trade if it is possible to do so, and the instances already mentioned demonstrate that they have made a beginning in this direction. That they intend to cultivate the branch is illustrated by the scheme which is now under consideration with a view to the formation of an export syndicate. Already syndicates exist for the inland market in so far as concerns joists, plates, and wire manufactures, and these have performed useful work by the prevention of a large amount of competition and by the maintenance of prices, but the regulation of the export trade would be wholly new for the iron and steel works. It is, however, doubtful whether the project will be brought to a successful issue unless the Russian Government comes to the aid of the works in a manner similar to that adopted in Germany, where the State railways transport export goods to the port of shipment at exceedingly low rates. If the Russian Government were to pursue a similar policy, it is possible that the iron and steel works in the south might be able to extend the export trade, seeing that their cost of production is low, but until that is done it is reasonable to assume that the export orders secured in the past few months represent isolated instances which, in all probability, will scarcely be repeated when the inland market in Russia assumes a normal condition, and the demand begins to absorb practically the whole of the production, as in former years.

THE United States Vice-Consul-General at Beirut has furnished his Government with a report, in which he states that an Imperial Turkish irade sanctioning the construction of an electric tramway in Beirut has been granted. The concession has been given for ninety-nine years in the name of Negib Pasha Melhame, a Syrian. Belgian capitalists immediately arranged to purchase the grant, and paid for the same the sum of £38,932. They have been compelled to pay £9733 as a loyal donation to the Hedjaz Railway and deposit a certain amount with the Imperial Ottoman Bank by way of guarantee for the execution of the venture.

LITERATURE.

Der Druck auf den Spurzapfen der Reaktionsturbinen und Kreiselpumpen. By Dr. Karl Kobes. Pub. F. Deuticke. 1906.

This is a treatise on the end thrust coming upon footstep bearings in reaction water turbines and centrifugal pumps. It is one of those laborious minutely exact mathematical studies of technical matters which always hail from German technical colleges, and which excite in the English reader (1) amazement, (2) awe, (3) respect, (4) impatience, and (5), not infrequently, contempt. The excuse for feelings (4) and (5) is based upon aversion to calculations of the hydraulic and hydrodynamic pressures on the end bearings extended to five, and even six, significant figures. The objections to such refinement of calculation are:—(A) The useful object of the calculation are to provide sufficient strength in the bearings, and to obtain knowledge of the frictional waste of power in them, and to adopt means to minimise this waste, while (*a*) the strength of the materials of the bearings cannot be known within 2 per cent. of accuracy, and (*b*) the coefficient of friction will certainly vary at least 10 per cent. from its mean, and its mean cannot be known within 5 per cent. of accuracy; (B) the said calculations are deduced from certain hydrodynamic assumptions, such as that of the whirl velocity of the water lying over a smooth rotating disc being half the angular velocity of the disc, which are adopted—by way of illustration of general formulæ—for the sake of simplicity of calculation, and which may differ from the actual physical condition existing in any particular turbine by any percentage between 0 and 50 or 60; and (C) the hydraulic pressures at the inlets of hydraulic machines do actually vary irregularly by several per cent. in consequence of very variable obstructive and disturbing influences in a score of places in the headrace and flume.

Further objection to such minute mathematical study might be based upon the fact that the treatise which analyses so completely the forces acting on the bearings offers no information of any kind whatever upon the constructions adopted for such bearings to withstand these forces and none upon the methods of lubrication used; nor does it offer any suggestions in either of these directions—there is not a diagram in the book showing even the outline of such a bearing nor a word of description of one. This criticism may, however, be possibly unjust. For all we know, Dr. Kobes, who is a professor in th Vienna Technical High School, may have written, or may propose to write, a treatise upon the design of such bearings; or he may argue that, in these days of division of labour, the calculation of the external forces is enough for one technical professor, and that the calculation of the stresses in the machinery due to these forces and the design of the parts to withstand these stresses belongs to quite another department of the technical college.

The preliminary objections being taken to the nature of Dr. Kobes' book, let us say that, within its scope, it is an unusually fine piece of work, and, moreover, that it develops most important practical results. After a preliminary exposition of fundamental principles and results, which is tedious in the usual German manner from its wearisome slow-plodding gait, it proceeds in its applications to various styles of turbine and to various parts of the machine in admirable terse and well-ordered fashion. Here, indeed—and this forms the bulk of the volume—the reading is difficult because of the condensation, the perpetual back-references to previous diagrams, equations, &c., in order to avoid repetition, and the abrupt changes from "case" to "case" due to the extensive classification and sub-classification of "cases," and the determination to deal fully with all of them. But this insatiable aspiration towards all-embracing completeness leads the author to be absolutely pitiless in the extension of his overwhelming array of algebraic letter symbols, simple and duplicated, open and bracketed, prefixed and suffixed, super-affixed and sub-affixed, plain and barred, accented and unaccented, caps and lower case and italics, light type and heavy black type. Only a German student-brain could avoid reeling in giddiness when hemmed in on all sides with such regiments of symbols. It must require special training in the memorisation of the arbitrary meanings attached to letter symbols to enable one to tramp at fair pace along these leagues of formulæ with recognition of their significance. Even then this would be impossible without the aid of diagrams, which give hints that help one along a little bit.

The important practically useful gist of the book is this: In a fluid whirlpool, centrifugal action creates an excess of pressure at the outside periphery over that near the centre of the whirlpool, the radial increase of pressure having, of course a continuous gradient. This unequally distributed pressure acts, not only radially on the cylindrical boundaries of successive portions of the whirlpool, but also axially on the disc surfaces which bound it transversely to the axis of rotation. The pressure at the periphery may be put in equilibrium with that in any other space by opening a sufficiently free passage between that space and the periphery of the whirlpool; and then the disc pressure of the whirlpool will throughout the disc surface be less than that in the communicating space. If such communication, however, be established near the whirlpool centre, then the disc pressure will be throughout greater than that in the connected space. Such a water whirlpool exists between the roof of a rotating turbine wheel and the fixed cover of the case in which it revolves. The pressure of the whirlpool upon the rotating roof-disc of the wheel is a very large part of the end thrust on the footstep bearing. Of course, it is partly balanced by the opposite pressure on the lower or inside of the same wheel roof-disc exerted by the working water as it flows through between the blades, these working water streams forming another whirlpool. In this latter whirlpool, however, the pressure has already been mainly spent in the generation of kinetic energy; and, in any case, this latter opposite pressure on the working face of the disc is chiefly conditioned by the necessary forms of the stream lines and the velocities along these lines required for the useful driving work to be done. It depends largely upon whether the turbine is of the type called "reaction" or of that called "impulse." The whirlpool of water between rotating roof and fixed cover can be modified in various ways. Its angular speed may be increased up to equality with that of the wheel by casting radial ribs upon the wheel disc; or the angular velocity of the great bulk of the water in this whirlpool may be reduced nearly to zero by casting similar ribs on the fixed cover. Again, free communication between this space and the tail-race immediately under the wheel may be established at the centre by casting holes in the disc near the hub. In this case the pressure over the wheel roof will be greater than that in the centre of the wheel at outflow. But communication between the draught tube and the periphery of the space between fixed cover and rotating disc may be established by a pipe, while this disc is left solid and unperforated anywhere; and in this case the mean downward pressure on this rotating disc will be less than that reigning in the draught tube. It will thus be less than the upward water pressure on the inside of this disc. There results an upward balance of pressure on the wheel which relieves the footstep of end thrust. According to calculation the magnitude of this relief may be very large, and may go a long way towards balancing the weight of the wheel and shaft. For instance, in a Francis turbine with vertical shaft and 2·4 m. wheel diameter, it may be five or six tons. Many examples are worked out in Dr. Kobes' book for several different styles of turbine. Of course, in proportion as the pressure on the footstep is decreased by such means, that on the fixed cover over the running wheel is increased, and this must be correspondingly strengthened.

The maximum relief is obtained when means are adopted to give the full whirl velocity to the water under the cover. It should not be forgotten that the maintenance of this whirlpool involves frictional and viscous work between the whirlpool water and the fixed cover, and in churning the water of the whirlpool itself. Thus the advantage of footstep relief is gained at the expense of some loss of mechanical efficiency at the wheel. We have failed to discover that Dr. Kobes points out this rather important consideration. It would appear possible, also, if the periphery of the case cover be pipe-connected with a part of the draught tube, where there is much less than atmospheric pressure, that the inner portions of the whirlpool space may be emptied of water; while long short of this degree of vacuum there will be considerable leakage of water through the shaft bearing in the cover.

In the second half of his volume the author re-states the whole case in terms of what he calls the "new theory." This is a theory of turbine action which has been developed by various authors in Germany during the last few years. It is based upon a very general analysis of "steady" whirlpool action upon a symmetrically disposed set of blades rotating about the whirlpool axis. It applies to stream lines in three dimensions, and as these lines in nearly all modern efficient turbines are twisted curves, such a theory is necessary for a full and correct treatment of turbine action. Compared with the theoretic treatment of only a very few years ago, this new method is not only vastly more elegant, but also very much more powerful in dealing with the somewhat complex shapes that the blades take in these newer designs.

If the matter of this book were placed before the English technical public in simpler form, so as to make it easier to read, it would make an important addition to our useful engineering literature—we mean that portion of our engineering literature which is really useful to engineering science and practice, and not merely helpful in preparing students to "pass" examinations.

SHORT NOTICES.

Memoirs of the Geological Survey of England and Wales: The Geology of the Country around Macclesfield, Congleton, Crewe, and Middlewich. By T. J. Pocock, M.A. London: E. Stanford, 12, 13, 14, Long-acre. Price 2s. 6d.—We have received from the Board of Agriculture and Fisheries a copy of a memoir on the geology of the country around Macclesfield, Congleton, Crewe, and Middlewich. This memoir is descriptive of parts of Cheshire and Staffordshire, including the northern end of the Potteries coalfield and portions of the coalfield and salt-bearing districts of Cheshire. This area, consisting mainly of carboniferous and New Red rocks, is extensively covered with drift, and a detailed account is given of these superficial deposits, together with notes on the shells from the high-level gravels of Macclesfield. Maps of different districts and vertical sections are given to a large scale.

Symmetrical Masonry Arches. By Malverd A. Howe, M. Am. Soc. C.E. London: Chapman and Hall, Limited. Price 10s. 6d. net.—The author explains in this book the method to be employed in the designing of masonry arches according to the elastic theory. The greater part of the book is taken up with the solutions of examples, giving each step in detail, so that those who have not the time fully to enter into the rather complex theory of arches may yet easily follow the examples. Ordinary mathematical and graphic solutions are given. For the benefit of those who desire to follow precedents, and as an aid in making preliminary calculations and estimates, the general data for over five hundred arch bridges have been given, in tabular form, with references to periodicals and journals when a more detailed description can be found.

Text-Book on Geodesy and Least Squares. By Charles L. Crandall. London: Chapman and Hall, Limited. Price 12s. 6d. net.—The book is an outgrowth of a course of lectures prepared for instruction at Cornell. It deals with geodetic, hydrographic, and topographic surveying. There are eleven chapters and thirteen tables, which have been again divided into parts, one and two, under the headings Geodesy and Least Squares. The subject does not appear to have received any special treatment. Care has been taken to explain fully the construction of different instruments, and the correct methods of using them. The drawings and other illustrations are clear, and have not been spoilt by having unnecessary details on them.

A History of the First Ten Years of Automobilism, 1896-1906. By Lord Montagu. London: The *Car Illustrated,* Limited, 168, Piccadilly, W. Price 2s. 6d. net.—The author has compiled a series of narratives, historical and retrospective, written by some of the best known pioneers of automobilism. The tribulations of the early motorist, both with regard to the attitude of the public and the idiosyncrasies of the cars, make interesting reading. The book is a history, or rather a compilation of historical facts without regard to the correct sequence of events, and the engineer who reads it must not expect to find a detailed account of the progress of the construction of motor vehicles.

Manual of Wireless Telegraphy. By Frederick Collins. London: Chapman and Hall, Limited. Price 6s. 6d. net cloth, 8s. 6d. net morocco.—To those who are interested in wireless telegraphy, and who have no great knowledge of the subject, we commend this small book. It describes in simple language the general principles on which the subject is based, and the diagrammatic representations of the apparatus are excellent.

BOOKS RECEIVED.

Die Turbinen für Wasserkraftbetrieb. Von A. Pfarr, Berlin: Julius Springer. Price M. 36.

The Royal Navy List and Naval Recorder. London: Witherby and Co., 326, High Holborn. Price 10s.

Elements of Mechanical Drawing. By Alfred A. Titsworth, M.Sc. London: Chapman and Hall, Limited. Price 5s. 6d. net.

Modern American Machine Tools. By C. H. Benjamin. London: Archibald Constable and Co., Limited. Price 18s. 6d.

The Law Relating to Railway Traffic. By Thos. Waghorn. London: Effingham Wilson, 54, Threadneedle-street, E.C. Price 2s. net.

Laboratory Work in Electrical Engineering. By John Roberts, jun. London: Harper Brothers, 45, Albemarle-street, W. Price 5s. net.

Engineering in the United States. By Frank Foster, M.Sc. Manchester: Sherratt and Hughes, 34, Cross-street. London: 60, Chandos-street. Price 1s.

The Inventor's Guide to Patent Law and the New Practice. By James Roberts, M.A., LL.B. London: John Murray, Albemarle-street, W. Price 1s. net.

The Truth about the Navy. With an Account of the Development of the German Fleet. London: Chapman and Hall, Limited. Price 1s. net.

The Principles and Practice of Surveying. By Charles B. Breed and George L. Hosmer. London: Chapman and Hall, Limited. Price 12s. 6d. net.

Elements of Sanitary Engineering. By Mansfield Merriman. Third edition, enlarged. London: Chapman and Hall, Limited. Price 8s. 6d. net.

Universal Dictionary of Mechanical Drawing. By George H. Follows. London: Archibald Constable and Co., Limited, 16, James-street, Haymarket, S.W. Price 4s. net.

Problems in Surveying, Railroad Surveying, Geodesy. By Howard Chaplin Ives and Harold Ezra Hills. London: Chapman and Hall, Limited. Price 6s. 6d. net.

The Minutes of the Proceedings of the Institution of Mechanical Engineers. Parts 1 and 2. 1906 Published by the Institution, Storey's-gate, St. James's Park, S.W.

Reinforced Concrete Construction. By A. W. Buel and Charles S. Hill. Second edition. London: Archibald Constable and Co., Limited. Price 21s. net.

The Marine Steam Engine. By the late Richard Sennett and Henry J. Oram, C.B. Eighth edition. London: Longmans, Green and Co., 39, Paternoster-row. Price 21s.

Ice Formation: With Special Reference to Anchor Ice and Frazil. By Howard T. Barnes, M.A., Sc.D.Sc., F.R.S.C. London: Chapman and Hall, Limited. Price 12s. 6d. net.

Steam Boilers: Their Management and Working on Land and Sea. Fifth edition. By James Peattie. London: E. and F. N. Spon, Limited, 57, Haymarket. Price 4s. 6d. net.

Clays: Their Occurrence, Properties, and Uses, with Special References to those of the United States. By Heinrich Ries, Ph.D. London: Chapman and Hall, Limited. Price 21s. net.

Service Chemistry. By Vivian B. Lewes F.I.C., F.C.S., and J. S. S. Brame, F.C.S. London: Henry Glaisher, 32, Charing Cross, S.W., and James Glaisher, 65, London-street, Greenwich, S.E.

A Treatise on the Theory of Alternating Currents. By Alexander Russell, M.A., M.I.E.E. Vol. II. London: The Cambridge University Press Warehouse, Fetter-lane, E.C. Price 12s. net.

Qualitative Analysis, Concise and Explanatory. By H. J. H. Fenton, Sc.D., F.R.S., M.A., F.I.C., &c. New edition. London: Cambridge University Press Warehouse, Fetter-lane, E.C.

Bread and Butter Studies, and their Relation to the Higher Education of Workmen. By William Ripper, M. Inst. C.E. London: Longmans, Green and Co., 39, Paternoster-row, E.C. Price 6d. net.

A Sketch of Scottish Industrial and Social History in the Eighteenth and Nineteenth Centuries. By Amelia Hutchinson Stirling, M.A. London: Blackie and Son, Limited, 50, Old Bailey, E.C. Price 6s. net.

Fire Tests with Floors. A Floor of Reinforced Concrete. By the Patent Indented Steel Bar Company, Limited, London. London: The British Fire Prevention Committee, 1, Waterloo-place, Pall Mall. Price 2s. 6d.

Principles of Microscopy: Being a Handbook to the Microscope. By Sir A. E. Wright, M.D. (Dublin), F.R.S., Hon. D.Sc. (Dublin), &c. London: Archibald Constable and Co., Limited, 16, James-street, Haymarket, S.W. Price 21s. net.

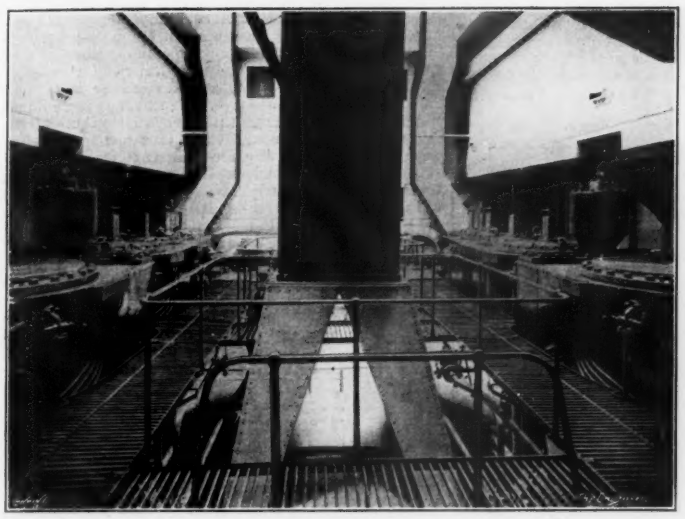
The Engineers' Sketch Book of Mechanicals, Movements, Devices, Appliances, Contrivance, and Details. Fifth edition. By Thos Walter Barber, M. Inst. C.E. London: E. and F. N. Spon, Limited, 57, Haymarket. Price 10s. 6d. net.

Building Contracts, Building Leases, and Building Statutes. By Joseph Bridges Mathews, Barrister-at-Law, and W. Valentine Ball, Barrister-at-Law. London: Butterworth and Co., 11 and 12, Bell-yard, Temple Bar, W.C. Price 27s. 6d.

THE ROYAL MAIL STEAMSHIP ARAGUAYA

THE MAIN STAIRCASE

FIRST-CLASS DINING SALOON



UPPER PLATFORM IN ENGINE-ROOM

BOILER-ROOM

THE ROYAL MAIL STEAMER ARAGUAYA.

IN our impression for Oct. 12th last we gave a general description of the latest addition to the fleet of the Royal Mail Steamship Company, the Araguaya. We now publish reproductions of photographs of the ship at sea, and also illustrate the passenger accommodation in some detail. Unfortunately, no photographs were taken of her engines, with the exception of one of the upper platform, which we reproduce.

The ship, we may remind our readers, is 533ft. long, 61ft. 3in. beam, and 43ft. deep. Her gross measurement is 10,537 tons. We have already spoken of the sumptuous character of her fittings. It is unnecessary to traverse the ground again. Three hundred first-class passengers are provided for. The "tandem" system of state-rooms is a remarkable improvement on previous ideas. By it each of the inner state-rooms on the upper, or "D," deck has a passage to the side of the vessel with an opening port, thus affording the same advantages of light and ventilation enjoyed in the outer rooms. Each cabin is provided with an electric ventilating fan. At intervals along the passageways on both port and starboard sides are placed drinking fountains continuously supplied with pure filtered iced water, and with regard to the bathroom and other accommodation it need only be remarked that it has been specially designed for tropical voyages.

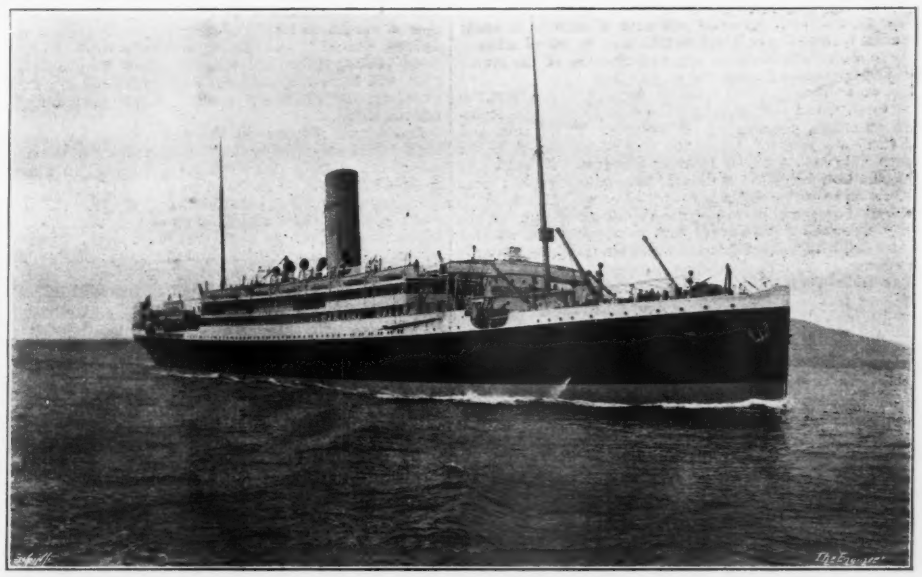
The second-class passenger is much better off than was the first-class passenger a few years ago. The third-class accommodation is excellent. The passengers are berthed on the main and lower deck forward.

The ship has a double cellular bottom, and, in addition to the five holds for cargo, there are no fewer than thirty watertight compartments, which, it is anticipated, will render the steamer practically unsinkable. The two forward and the aftermost lower 'tween decks and holds have been insulated, and prepared for the conveyance of cargo requiring cold storage, and preparations of a similar nature deal with the supplies for passengers.

The two sets of engines have been constructed by the builders of the hull, Messrs. Workman, Clark and Co., Limited, Belfast, and the separate parts have been designed and balanced, to reduce the vibration to a minimum. The engine-room is, as we have already stated, very large, and the arrangements for lighting and ventilation are such as must add greatly to the comfort of the staff in charge. The engines are of the quadruple-expansion type, with four inverted cylinders and four cranks. The high-pressure cylinders are 27in. in diameter, the medium-pressure cylinders 38in. and 54in. in diameter respectively, and the low-pressure cylinders 76½in. in diameter, while the stroke is 4ft. 6in.

The cylinders are all independent of each other, the liners are of hard cast metal, and the cylinder covers are double, strongly ribbed, and have polished corrugated tops. The high-pressure and the first intermediate cylinders are fitted with piston valves, working in separate valve-casing liners. The second intermediate-pressure and the low-pressure cylinders have double-ported valves. Starting valves, of the mitre type, are arranged to be worked from the starting platform. The reversing engines are of the steam and hydraulic type. All the columns are of cast iron, the front columns on each engine being adapted for use as oil tanks, with filling pipes from the deck and draw-off cocks at foot.

The engines are so arranged that the starting platform is in the centre of the ship, and the engineer-in-charge is thus enabled to command a view of practically the whole of the machinery under his charge. The main condensers are placed on the outside of the engines, and attached to the back of the columns by brackets. The circulating water is supplied by two large slow-speed centrifugal pumps of Messrs. Workman, Clark and Co.'s own make, of sufficient size to maintain the necessary vacuum when the engines are running at full speed in the tropics with the sea water at 85 deg. Fah. The bilge, air, and sanitary pumps are driven by the main engines, the independent sanitary pump, ballast pump, and other



THE ARAGUAYA AT SEA

auxiliaries being supplied with steam by a special range of pipes, and all the exhausts are led into an auxiliary condenser fitted with combined air and circulating pumps.

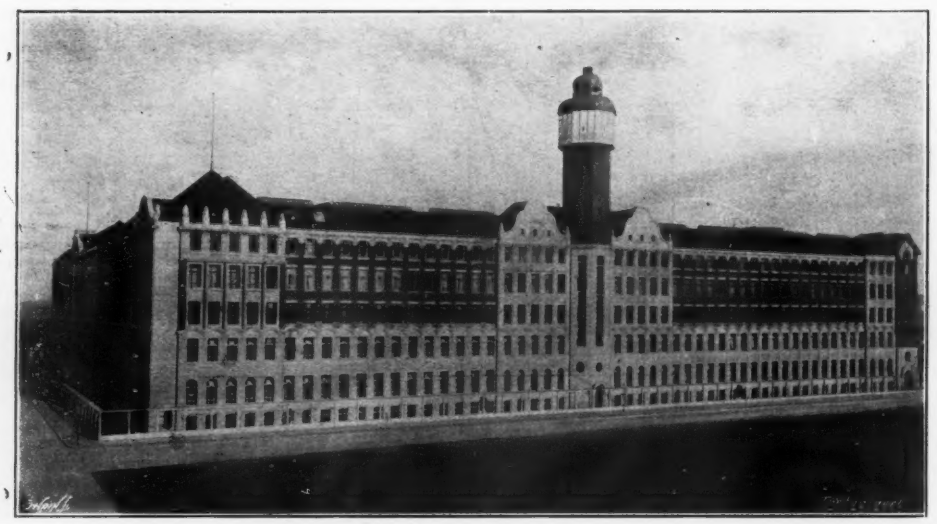
The crank, tunnel, and propeller shafting is of steel considerably increased in diameter beyond the Board of Trade requirements, and the crank shafts are of the built type, and constructed in interchangeable sections. The propellers are of bronze, each propeller having three adjustable blades, and runs outboard.

Steam is supplied by six steel Scotch boilers, designed for a working pressure of 215 lb. per square inch, and so arranged as to be fired from two stokeholds. The boilers are fitted with forced draught on Howden's open stokehold system, the air being supplied by two fans, placed in recesses in the after stokehold. Each stokehold is provided with See's ash ejectors, and subsidiary ash hoists in addition. The furnaces are thirty-six in number, of Deighton's withdrawable type, each boiler being fitted with four furnaces. The space between the propeller shafts has been utilised for the refrigerating machinery—Hall's—which consists of a horizontal duplex marine type of engine for the CO_2 system, fitted with the necessary compressors, evaporators, and pump, and is capable of dealing with cold chambers having a capacity of almost 200,000 cubic feet.

The vessel is fitted with electric light, and the 16 candle-power lamps are distributed throughout the first, second, and third-class accommodation, and in all machinery spaces and stores, suspended either from brackets, or, as in the case of the public rooms, machinery spaces and cargo holds, in clusters, and the whole system of lighting is such that every room and corner has its service. There are four main dynamos, each driven by a separate engine of the inverted cylinder type. The deck machinery consists entirely of hydraulic cranes, the motive power for which is situated in the aft end of the engine-room, and fitted up with every detail of the most approved type.

A GERMAN ELECTRICAL FACTORY.

THE numerous works of the electrical firm of Messrs. Siemens and Halske, which were formerly distributed over several parts of Berlin and Charlottenburg, are being united on the ground recently purchased by the company on Nonnendam, near Berlin. The new works are to be called "Wernenwerk," and may be taken as the latest word in factory construction as developed in Germany. The accompanying illustration shows a front view of the building.



SIEMENS AND HALSKE'S NEW WORKS NEAR BERLIN

The ground plan was laid out with a view to a ready extension both to the east and south, and to afford adaptability to all requirements in the manufacture of the multiplicity of apparatus constructed by this firm.

The works comprise four main buildings, running from the west to east, and each of which is connected to three transverse buildings, forming six courtyards. To the west and east there are rows of workshops, which are placed in the best possible conditions for lighting purposes. By means of light partition walls, the standard workshops running from one transverse bay to the other can be converted into half-standard shops, or else into shops running throughout the building, special regard being had to any necessary accessory rooms, lifts, &c., so that the workman need not leave his workshop.

A special point has been made of designing the building in a way as practical and as economical as possible, using, for example, standard designs for the pillars, doors, and windows.

As will be seen from the engraving, the works, however great may be their utility, can hardly be called handsome. The water tower projecting from the whole building is visible to a great distance. In order to give an idea of the dimensions of the works, it may be said that its corridors and conveying galleries aggregate a length of 5 kiloms. Some 5400 piles, each 5 m. to 10 m. in length and 30 cm. to 36 cm. in diameter, 5300 cubic metres of concrete for the foundations, 7,000,000 bricks, 2900 tons of iron structure, 13,200 cubic metres of concrete for the ceilings, and 14,600 square metres of glass have been used in erecting the works.

As regards the water supply, the best means was found to be a connection to the Charlottenburg water works. The whole of the supply of electrical energy is derived from a central station intended to feed all the factories to be erected later on, the Werner works being connected with this central station by power and light cables leading the current to the places of consumption. These cables terminate in the works in the transverse building which lies closest to the power station, where both the light and power cables are united in pairs of bus bars, there being also four single-pole switches, enabling the lighting system to be combined with the power system in the case of a breakdown in the cables. As the cross sections of the latter are very large, either group will be able temporarily to cope with the whole of the current supply.

As regards the electrical equipment, the motors driving the shaft lines should be mentioned in the first place. Individual operation has been chosen only in the case of a few machine tools. Whenever possible each line of shafting in a given shop is worked by a special motor. Further, motors are used for the lift and for twelve goods elevators, while other motors are set apart to operate the compressed air and ventilation plant. The lighting system serves to feed both the lamps and experimental instruments.

Steam for heating is supplied from a central station to a heating plant designed on the Krantz circuit system, while the steam for power purposes is generated independently in a special boiler erected in one of the courtyards. The chimney for the boiler is hidden in the water tower.

A special feature of the new works is the intelligence transmitting plant, in which both telephones and type printing telegraphs are used. A special central station is provided for the telephone and telegraph service both within the works and with the city.

Another model plant is the fire-signalling station combined with the guard-checking service; 83 fire-signalling and checking apparatuses have been arranged in three guard districts, both within the vast building and outside in the courtyards. In a few rooms in which the risk of fire, owing to the combustible matter stored in them, is especially great, an automatic signalling apparatus has been provided, including a set of signalling instruments in which any excessive increase of temperature due to a fire will burst a glass cartridge filled with liquid, thus opening a pair of springs and interrupting a current continuously traversing the circuit, when a valve corresponding to the room in question will drop on a switchboard installed at the signalling station, causing an alarm to ring. While a well-organised house fire brigade, comprising a number of trained workmen of the joinery and packing shops, will be able in most cases to deal with a fire, a special alarm from a porter's cabin may, whenever required, call the professional fire brigade of the city of Charlottenburg. Each hall is fitted with a signalling bell connected to the standard clock, which serves to give time signals. Many foremen's offices are connected to the store-rooms, which are situated at a lower level, by what is called a "ball-mail"—that is, a tube through which there runs a hollow wooden ball, containing a paper, on which the order is written.

The shops are divided into general and special shops. In the former the manufacture of the various parts of an article is carried out, while in the latter these parts are mounted, adjusted, standardised, and finished. Beside extensive general workshops for the working of metals, such as milling, drilling, punching and turning, and the smithy, there are the wood-working shops, and those set apart for the working of glass and leather, in addition to large painting, varnishing, nickeling, bookbinding, spooling, drawing, staining, and brazing shops.

Above each machine in the pattern-making shop a tube with a wide mouth is fixed. Through this the shavings are sucked off, in order afterwards to be collected in a cowl and to be carried away in carts.

Among the apparatus manufactured at the works should be mentioned telegraph, commanding and signalling apparatus, telephones and whole telephone exchanges, fire-signalling apparatus, measuring instruments, and electro-medical outfits.

The electro-chemical department is intended to deal with a number of interesting problems, such as those of electrolysis and electro-metallurgy—inclusive of the electrical manufacture of steel—the production of calcium carbide and nitrogen from the atmosphere, the applications of ozone, besides a number of other subjects. This department has been installed in the large courtyard adjoining the building.

Special arrangements have been made to render the factory as comfortable a place for the 5000 workmen as possible. A colony has also been built in the neighbourhood of the factory on the hitherto vacant ground. This forms quite a little town of its own, and affords ample dwelling accommodation. A special railway station close to the works and a bridge leading across the river Spree have been constructed in order to obtain an easy access to the works from the city and its suburbs.

THE ENGINEERING SOCIETY, EAST LONDON COLLEGE.—A paper on "The Design of a Petrol Motor," was read before the above Society on December 12th by Mr. A. P. Thurston, B.Sc. The author dealt, step by step, with the method adopted to design a motor to a given specification, briefly touching upon the governing conditions, and showing how to deal with the points arising. An interesting discussion followed.

ALCOHOL FOR COMMERCIAL PURPOSES IN THE UNITED STATES.

ACCORDING to a published statement in the *American Record*, the regulations of the Internal Revenue Commission of the United States under the new law regarding the use of denatured alcohol will practically prohibit its use for motors and power purposes, although they are fairly liberal as regards its use for industrial purposes.

Distillers of grain or ethyl alcohol will be permitted to denature it before its removal from bonded warehouses, after which it can be withdrawn without the payment of internal revenue tax. The general denaturing agent will consist of methyl alcohol and benzine in the following proportions:—To every 100 parts by volume of ethyl alcohol of the desired proof—not less than 180 deg.—there shall be added 10 parts by volume of approved methyl alcohol, and half a part by volume of approved benzine; for example, to every 100 gallons of ethyl alcohol—of not less than 180 deg. proof—there will be added 10 gallons of approved methyl alcohol and half a gallon of approved benzine. Alcohol thus denatured will be classed as completely denatured.

Completely denatured alcohol may be withdrawn from bonded warehouse free of tax, either by a manufacturer or general consumer or a wholesale or retail dealer therein. If a manufacturer uses less than an average of 50 gallons of denatured alcohol per month he will not be required to secure a permit, but if he consumes more than that amount he will be required to obtain a permit from the Collector of Internal Revenue for the district in which his plant is situated. Any one desiring to use completely denatured alcohol for an internal combustion engine may buy it in any desired quantity. Dealers who sell less than five gallons are to be classed as retailers, and those selling more than that amount are to be rated as "wholesalers." Denatured alcohol cannot be sold in quantities of five gallons or more except in the original stamped packages.

In the production of completely denatured alcohol, agents are used which render the resulting product unsuited for some industrial purposes, and the regulations will accordingly permit the use of special denaturants under conditions to be determined in each individual case.

Denatured alcohol used abroad for power purposes is enriched by the addition of a petroleum distillate of a grade somewhat like benzine. The new American regulations do not permit consumers of denatured spirits to add to or take from them anything whatever, and therefore it would not be practicable to add benzine without special authority from the Internal Revenue Bureau. The Commission, however, is prepared to consider any formulas that may be submitted in this connection, and if satisfied that they will produce an article that may be safely classified as completely denatured it will apply the appropriate regulations thereto. The experts of the Bureau recognise the fact that completely denatured spirits for power purposes must be relieved of restrictions if they are to compete with gasoline and other petroleum products; therefore if special formulas for completely denatured spirits are approved, such spirits will be permitted to be used without any restrictions except those that apply to alcohol completely denatured with the general agent prescribed by the regulations.

LIGHTNING CONDUCTORS.

ON the 6th inst. Mr. Alfred Hands, F.R.Met.S., delivered a lecture before the Royal Engineers at Chatham on "The Protection of Buildings from Lightning." He showed the extent of damage by lightning by means of a chart of England and Wales, on which the positions and nature of objects damaged during a period of about nine years were indicated by coloured spots. This included 2485 buildings, of which 148 were churches. He criticised the Report of the Lightning Research Committee, which, he said, by its contradictory recommendations and incorrect statistics, had caused a great deal of scepticism as to the utility of lightning conductors. He showed by diagrams and reproductions on models of buildings of cases that had occurred some of the more complex lightning effects that had to be guarded against, and the methods of protection that had to be employed. These included fires caused by the surging effect of a discharge, and cases in which damage is caused to a building by lightning striking an object half a mile away.

The lecturer showed the impossibility of protecting buildings efficiently by means of set rules; each case had to be studied separately, and the system of protection applied which the complications of metal in and about the structure showed to be necessary. Hitherto too much importance had been attached to the form and composition of the conductor and too little to the fact that its efficiency depended almost entirely on the way in which it was applied and very little on what it was. He regarded the subject as somewhat analogous to the work of a medical practitioner. The conductors in the hands of an expert were comparable to the drugs a physician might find it necessary to prescribe according to his diagnosis of the case. No one could claim infallibility, and anyone might overlook some factor that might have an important bearing on the case; but the fact remained that the possession of knowledge, experience, and an ability to discriminate as to the importance of details should enable a man to protect a building effectively, while absence of these would very probably result in failure. At all events, it was in this direction he thought we should strive to improve our methods, and not in trying to devise theoretically perfect but practically impossible mechanical ones.

As regards the relative value of iron and copper for conductors, he considered the matter, so far as concerned conductivity and the dissipation of energy, to be of such trifling importance that it sank into insignificance in comparison with considerations of durability. A lightning conductor was expected to last for a long time, and iron was unfortunately too perishable for the purpose. As regards cost, an iron system, if of sufficient size to be fairly lasting, would be more costly than an ordinary copper tape one.

Mr. Hands said that vagaries or freaks of lightning were an impossibility, and the belief in such was due only to the cases being wrongly reported. There were laws governing all natural phenomena, and lightning, like every other force in Nature, must be amenable to law. Where they appeared at first sight inexplicable we should try to clear up the mystery, and not dismiss the matter by saying that in one respect Nature was erratic.

DEVELOPMENT OF THE FRENCH AUTOMOBILE INDUSTRY.

No. II.*

THE internal combustion engine has until recent years received far more attention from automobile engineers than any other part of the car's mechanism. At one time there was a vague hope that the petrol engine would eventually improve away much of the propelling machinery, or, at least, would simplify the transmission to a considerable extent. The old problems of varying compressions, of utilising the gases expansively, and the like resulted in the production of a large number of novel engines, and gave a decidedly interesting character to the annual shows, but of late the automobile engineer has been displaying more and more scepticism towards anything which offers a radical departure from the usual practice. The manufacturer has been working upon the motor problem in every possible way. He has followed up and developed all sorts of ingenious theories which, at the time, seemed likely to bring about an entire change in the automobile industry, but he has always been obliged to come back to the ordinary type of four-cycle engine, and there is nothing yet to show that it is likely to be superseded by any better type of prime mover. Nevertheless, it can hardly be said that the efficiency of the petrol engine has been increased to anything like the extent that would seem to be warranted by the vast amount of ingenuity that has been centred upon this mechanism. Where makers have not been able to clear away difficulties they have worked round them with more or less success, until the internal combustion engine is now fulfilling all the conditions that may be reasonably expected of it. Still, no one will admit that it has yet reached anything like finality, and in the experimental departments of all the different works tests continue to be carried out with different types of engines, although little evidence of this is seen at the Salon, where inventors have, as a rule, learnt the futility of showing novel systems of engines that have not had their merits demonstrated by practical results. The principal drawback to most of the engines that have been brought out from time to time is their complication, which is regarded as fatal to success in the automobile industry.

Every attempt at obtaining a more constant turning force by the application of the rotary principle or by the use of other devices have failed because they give rise to new difficulties, and in view of these repeated failures makers have contented themselves with getting the most out of the ordinary type of engine with the aid of improvements in carburetters and by a more rational arrangement of the valves. They have, moreover, been hesitating a long while as to the best combination of angular speed and compression, and even now automobile engineers are not settled as to the best practice to be adopted. While a few of the leading firms still employ high compressions, the majority are not disposed to adopt a means of securing a higher efficiency that will only have the effect of increasing the difficulty of starting the engine, although it is probable that this difficulty may be overcome in the future by the general use of self-starting devices. For the moment it is an advantage to provide as easy a starting engine as possible. The battle between the long and short-stroke engines seems to be terminating in favour of the latter, although for industrial engines preference is being given to the slower running type, which is likely to maintain an advantage in cases where economy and durability are primary considerations. Nevertheless, with the systems of carburetters employed, and the materials used in the construction of engines, the difference in economy and durability between the two types is much smaller than was formerly the case. For pleasure vehicles large bores are being given to engines, whereby the power is increased with very little addition in weight. As a matter of fact, many firms have been simply enlarging the bores of their standard types of engines, with the result that, while they are still rated at their former powers, they are actually developing considerably more, and the powers of engines are now so misleading that it is becoming the practice to give the bore and stroke of the engine without indication of horse-power. This under-estimating of horse-power is particularly inconvenient for makers of transmissions and parts, who have been obliged to provide a sufficiently large margin, with the result that in all high-class cars the vehicle is much stronger and more powerful than it is represented. There has been singularly little change during the year in engine design, the prevailing practice still being to cast the cylinders in pairs, with the valve chambers on each side, although many well-known makers still cast their cylinders separately. This spreading out of the gases is not favourable to high efficiency, but the chambers on each side of the cylinders give a symmetric appearance to the engine, and also provide greater facilities for adjustment. This question of inspection and adjustment has been receiving particular attention from French automobile engineers, who mostly provide inspection plates over the pistons and over the valve chambers, these being kept down by dog irons, which can be instantly removed by a tool without touching the engine. We also notice a tendency towards giving as large dimensions to the valves as possible, this having been rendered possible by the use of a mechanically operating gear for the induction valves, and it is significant that the only big firm which has hitherto adhered to the automatic type of induction valve is this year following the general example of actuating the inlet valves mechanically. The use of these larger valves has created some difficulties in their manufacture. At one time it was the practice to construct them of pure nickel, but owing to the liability to breakage nickel has now been abandoned in favour of steel with a high content of nickel and a low percentage of carbon. With reference to materials, it may be mentioned that the use of special steels is not now so general. Steel with about 2 per cent. of nickel and 0·1 per cent. of carbon is the most extensively used, and vanadium steel seems to be gaining in popularity. Several new alloys for which special claims are made have recently made their appearance on the market, but experience is wanting to show whether these claims are at all justified.

The use of steel for cylinders has now been entirely abandoned except by one or two firms; but, on the other hand, the Forges de Denain exhibited at the Salon pressed steel pistons which are having a favourable reception. Most firms are endeavouring by this or other means to reduce the weight of the reciprocating parts. In car buretters there is a singular absence of novelty, and it was difficult to find any new devices in the show which represented a distinct advance on the ordinary types of automatic apparatus. The same principle is adopted everywhere of providing an additional air inlet which is actuated either mechanically or by the suctional effort of the engine on a rubber diaphragm. A year ago it seemed likely that the practice of using two jets would be extensively adopted, the supplementary jet coming into play as the engine accelerated, but this was only seen on two or three types of cars, and apparently the system has not proved to possess any superiority over the usual type of carburetter. The old question of whether the carburetter should be connected up close to the induction valves, or whether a long passage should be allowed to the gases, whereby they might become more thoroughly mixed, has been solved in most cases by fixing the carburetter on the exhaust side and carrying the induction pipe over between the cylinders, where the gases are not only thoroughly mixed, but are raised to a sufficiently high temperature to avoid condensation. This, of course, facilitates the production of a homogeneous mixture, but at the same time the higher temperature of the gases tends to reduce the quantity admitted into the cylinders.

* No. I. appeared December 14th.

DOCKYARD NOTES.

THE Drake has managed to add yet another to her many records. The last speed trial of the Second Cruiser Squadron was thirty hours at 4/5, and then home at 18 knots. The Drake, for her thirty hours, put up an average speed of 22·5 knots, which is about half a knot in excess of her original trial result at 4/5. She beat the rest of the squadron easily, the Cumberland and Cornwall, which have tried to break her record, being left far behind. On the previous full-power race for eight hours the latter ship beat the Drake, though not succeeding in beating the Drake's record by a knot. The flagship, however, allowed it as a defeat. She has now handsomely recovered her laurels, and bids fair to do with her new chief as well as she did under her old one.

WE gave recently in this column some German coaling records, and stated that the results obtained are half as good again as any of the records of our own Navy. Now we note that on Wednesday last week the battleship Goliath, whilst coaling from the Temperley depôt at Portsmouth, took on 1600 tons of bagged coal at the rate of 313·4 per hour. This coal was all taken on "according to the rules of the game," *i.e.*, it was all properly placed in the bunkers.

AMERICAN ENGINEERING NEWS.

The New York tunnels.—In connection with the new railway terminals, and the new underground electric tramway system of New York, there are being built no less than fourteen submarine tube tunnels. The six Hudson River tunnels include four—two pair—for electric tramways, connecting with a tramway subway in New York, and with surface suburban lines on the other side. Two are already completed, and the other two are well advanced; they are all 15ft. 3in. inside diameter, and 5100ft. long. The other two tubes are for the Pennsylvania Railroad, bringing that road into a great underground station, and doing away with the present service of steam ferries on the river. These tubes will be 19ft. inside diameter, and 6000ft. long between the shafts; the headings of both tunnels have been driven the entire distance. The Pennsylvania Railroad will extend completely across the city, and pass under the East River by four 19ft. tubes about 7000ft. long, the line coming to the surface to connect with extensive goods terminals and shipping docks in Long Island City. At the south end of the Island the Rapid Transit Commission is driving two tunnels, 15ft. 6in. diameter, and 7000ft. long, across to Brooklyn, forming an extension of the New York City Underground Railway. Farther north, at Forty-second-street, a tramway company is driving two tunnels, 15ft. 6in. diameter, and about 17,000ft. long, connecting with tramway subways in New York, and with surface tramways on the other side of the river.

New York aqueduct.—The aqueduct to bring a new water supply to the city of New York from the Catskill Mountains will be over eighty miles in length, and will cross beneath the Hudson River. It will be partly built as a concrete conduit in cutting and on embankment and partly a tunnel, the tunnel being lined with concrete. In inside dimensions it will be 17ft. high, with a maximum width of 17ft. 6in., except that in the tunnels the width will be 13ft. 4in. The roof will have a radius of 6ft. 4in., and the invert 32ft., while the sides will have a radius of 32ft. At one point a stream will be crossed by a concrete inverted syphon 11ft. in diameter. In the open work and cut-and-cover the aqueduct will be covered by an embankment, having a top width of 15ft. and a minimum thickness of 3ft. above the arch. Embankments to carry the aqueduct are to be built of carefully selected earth deposited in 3in. layers and containing no stones larger than 3in. The earth will be well watered and rolled, and compacted by the wagons hauling the material. Three 30ft. sections of 11ft. of gravel concrete are to be built for experimental purposes. The base will be 15ft. 9in. wide and the arch 8in. thick. It will be reinforced by rings of twisted and welded steel bars and twelve longitudinal lines of 1in. bars. Most of the concrete will be composed of one part Portland cement to eight parts of a mixture of sand or screenings with gravel or broken stone from ¼in. to 2in. in size. It must be mixed by machine, and the forms must be lined with sheet steel to give a smooth face finish.

THE SUBMARINES AND SUBMERSIBLES OF FRANCE.

(*By a French Correspondent.*)

FRANCE was the first nation seriously to adopt the submarine for warlike purposes. In 1885 she possessed the trial vessel the Gymnote, which managed, even at that period, to solve a good many problems in connection with submarine navigation. This little vessel, which only had a small displacement and a very restricted radius of action, since it was entirely operated by electricity, was for several years used as a boat for trial purposes rather than for fighting. However, in 1888 the general idea was taken up upon a wider basis, and a submarine of considerably greater displacement was commenced by the naval authorities, but was not completed till 1895.

In the meantime a civil engineer, Monsieur Goubet, invented a transportable submarine, which he named after himself. It was launched in 1891, but, although considerable ingenuity had been evinced in its design and construction, its trials did not satisfy the naval authorities, who refused to accept it. The inventor, in spite of this rebuff, set about to construct another vessel on more or less the same lines, but more perfect in its action. The private trials of this second boat were apparently eminently successful, and again the invention was offered to the State. It was again refused. The authorities, however, testified to their appreciation of the inventor's apparatus, and of the following capabilities of which it was possessed:—Sinking while at rest, whereas previously it had only been possible to do this readily when the vessel was in motion and by the aid of deflecting planes; motion at a predetermined depth without going off its course; motion on the surface in bad weather without being inconvenienced by the waves; and steering without a rudder, the propeller shaft being articulated, and taking the place, not only of the rudder, but of the raising and lowering planes.

Due largely to the data obtained with this boat, the naval submarines made rapid progress, and this type of boat was deemed to be necessary to the French navy. In 1896 the French Admiralty asked for tenders for a submarine with its accessories. The specification called for a speed of 12 knots on the surface, and a radius of 10 miles at 8 knots when submerged. The armament was to consist of two torpedo tubes. The next year numerous plans were submitted for complete submarines, as well as for accessories. The most noteworthy were, first, those of the engineer, Laubeuf, who gave to France a new type of boat, which was to have a great future—the submersible; secondly, those of M. Romazzotti, engineer of naval constructions, for a submarine pure and simple; and, lastly, the torpedo carriers of the Russian engineer Drezwieski, which allowed of the omission of the torpedo tube and accessories.

From this time onwards France made rapid strides in submarine navigation.

In 1895 the Gustave Zédé could sink to a depth of 12 m. At 8 knots, with 25 deg. of rudder, and without heeling more than 5 deg., it could turn in a circle of 180 m. diameter. In some of its trials it ran at a speed of 9 knots during eight hours. In the same year Goubet II. carried out its trials. She was pointed at both ends, and her plates varied in thickness from 7 mm. to 22 mm., according to their position in the hull. They were of bronze. The motive power was electricity, and the boat carried two torpedoes.

In 1897 the Gustave Zédé ran into the torpedo boat No. 139. The latter had only seen that it was in the course of the submarine when the boats were but a few yards apart, and too late to change its direction. The submarine hit the torpedo boat aft and burst in a compartment, which filled so rapidly that the vessel had to be beached at once. The submarine suffered no injury. At this time the problems of immersion at will and the maintenance of motion at any desired depth had been solved. In 1898 some experiments were made which showed that the Zédé was invisible at a distance of a mile even when it was moving at the surface. This boat was definitely incorporated in the fleet in June, 1899.

The Morse, another vessel, which was also added to the fleet in 1899, developed on her trials a speed of 12·32 knots. For the greater part of her length forward she was shaped like a porpoise, but aft her form was similar to that of a Whitehead torpedo.

In 1899 a public subscription got up by the newspaper *Le Matin* enabled two submarines, Français and Algerien, to be laid down. They were of the same design as the Morse, and in this year also an important event was the launching of the Narval, a submersible built in accordance with the designs of M. Laubeuf. This vessel externally had the aspect of a torpedo boat of small displacement. Below water level she was similar to the 130 type. She had two shells. The interior was like that of a Whitehead torpedo, and the space between the two shells was utilised for water ballast, the water being let in or pumped out according as it was desired to sink or to remain at the surface. There were two rudders, one for vertical and one for horizontal motions. The air reservoir was placed aft. To make it certain that the boat would rise to the surface, there were external lead weights which could be detached from inside the hull. The motor for navigation on the surface, or half immersed, was a steam engine which was worked by a petrol-fired boiler. During her trials the Narval did 252 miles at 12 knots, and 624 miles at 8 knots, which gave her a radius of 24 and 78 hours' steaming respectively. In 1900 she actually did 13 knots. The motor for submarine work was electric, and it was fed by a battery of 158 accumulators. With this motor the vessel travelled 25 miles at 8 knots, and 70 miles at 5 knots. The accumulators were charged by means of the main steam engine driving a dynamo when the boat was at the surface. The Narval was fitted with four Drezwieski apparatus for Whitehead torpedoes. The crew was composed of two officers and eight men.

This type of vessel was definitely incorporated in the

FRENCH SUBMARINES AND SUBMERSIBLES

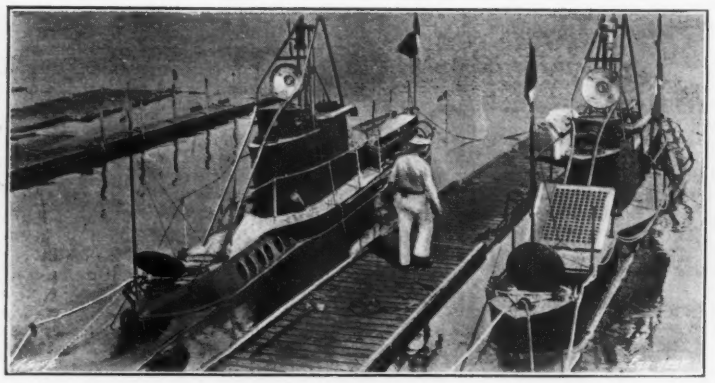


Fig 1—THE NAIADE TYPE

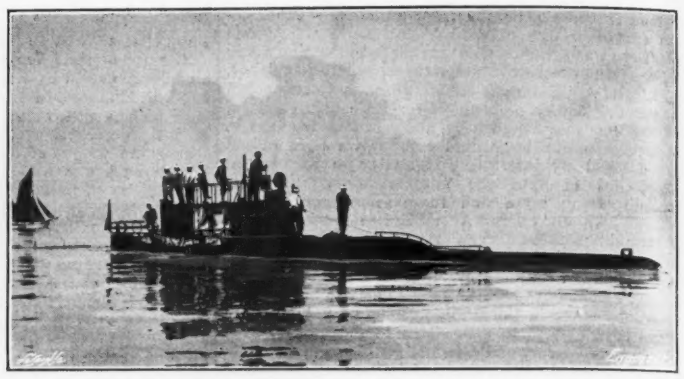


Fig 2.—THE LATEST TYPE OF FRENCH SUBMARINE

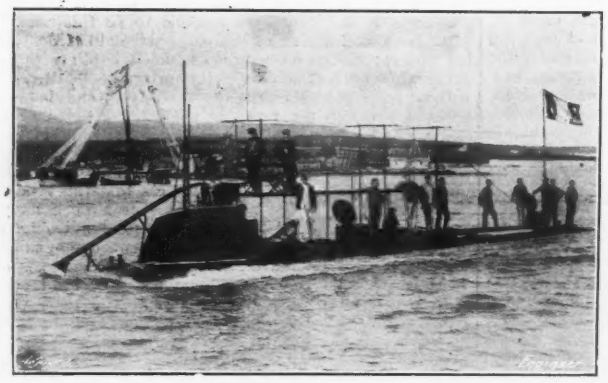


Fig. 3—THE LUTIN LEAVING BIZERTA HARBOUR

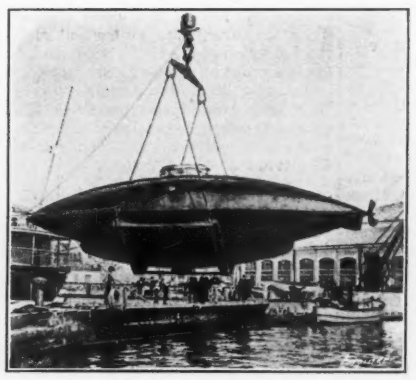


Fig. 4—THE GOUBET No. II.

Fig. 5—THE SUBMARINE GYMNOTE

active fleet in June, 1900, and from this time France possessed boats which could reach Corsica, Sicily, and Malta, as well as parts of the coast of Italy. With Oran as their home port, they could get as far as Gibraltar, and from Cherbourg or Dunkerque they could sail along the coasts of England.

The year 1900 saw the construction of four submarines of the Farfadet type, and the naval programme included a fleet of thirty-eight vessels, counting the submersibles.

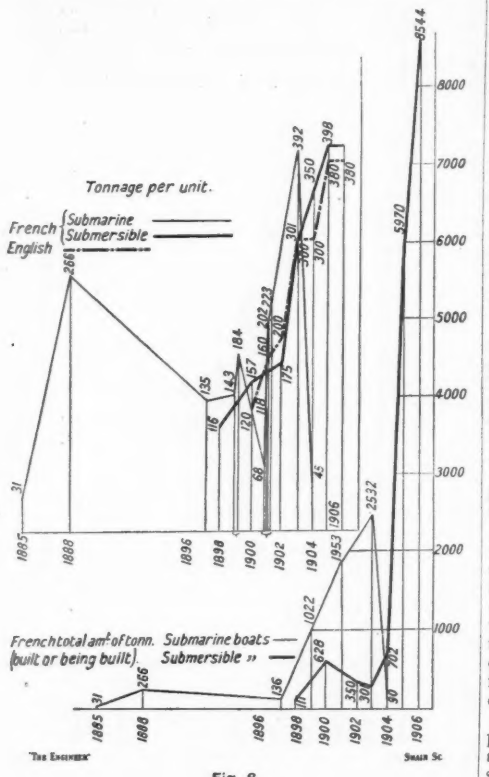


Fig. 6

In May of that year a fleet of submarines for defence purposes was stationed at Toulon for the first time, and in the same year some remarkable experiments to show the habitability of the Morse and the Narval were carried out. Both vessels remained under water for twelve hours with their full complement of men, and none of these felt any fatigue. In the same year the submersible Sirene was occupied for eleven hours in diving and in attack manœuvres against the northern squadron.

In 1902 three submarines and five submersibles made numerous attacks on the same squadron, which was protected by a fleet of destroyers and torpedo boats. These attacks were carried out over a line 20 miles in length. In the same year the submersible Silure descended to a depth of 39 m.—126ft. 3in.—and at the manœuvres just mentioned it often sank to depths of 18 m. and 20 m. so as to pass safely under the hulls of destroyers. and to attack cruisers under the most effective conditions.

During the years 1902, 1903, and 1904, submarines and submersibles under their own machinery frequently journeyed from Cherbourg to Brest and back, in all sorts of weather and notwithstanding fog. It had been realised in 1902 that bad weather had less effect on them than on the torpedo boats detailed to accompany them. The fuel capacity was large enough to prevent the necessity of taking any supplies at Brest, and the return voyage represented a distance of 180 miles.

Comparative trials between submarines and submersibles were made in 1904. The latter were much preferred by the crews, and showed themselves greatly superior in every respect to submarines pure and simple, except as regarded the rapidity of plunging, though the actual difference in time was not considerable. The submersibles are better sea boats in bad weather; their manœuvering qualities are much superior to those of the submarines, and are practically equal to those possessed by torpedo boats of the same tonnage.

In 1904 experiments were made with the first submarine fitted with a petrol motor for surface work in addition to the electric motor for under-water work. This submarine had a displacement of 202 tons, and was decidedly more comfortable to work in than any of the others which had preceded it, thanks to its superstructure forward. The designer was the naval constructor, M. Maugas. Comparative trials were made between this vessel and the Aigrette of M. Laubœuf, in which the latter showed an undeniable superiority before a Special Commission appointed by the Minister of the Marine.

The year 1905 was marked by the sad accident to the Farfadet—an accident attributed to the negligence of its commander, who delayed too long in closing the manhole in the conning tower—or, as the French call it, the kiosk—and was surprised by the sudden descent of the submarine. As a result of carrying out the same manœuvres time after time and of living constantly face to face with danger, the work finally got to be done perfunctorily instead of, as at first, having the greatest care bestowed on it.

In this year—1905—Calais was made a submarine base port, with the object of commanding the Channel up to a certain point, and of protecting Dunkerque and the surrounding districts, while at the same time threatening the English coast.

In February, 1906, came the accident to the Bonite. The Toulon submarine flotilla was manœuvring against a squadron which had arrived off the port, and the Bonite had successfully torpedoed the armoured cruiser Condé and the battleship Iena at distances of about 200 m. (218 yards), when it was decided to make an attempt to torpedo the Admiral's flagship Suffren. To do this it was necessary to sink to a depth of 20 m. so as to pass under some destroyers. A course was made for the flagship, and after a short interval the submersible was brought to the surface so that the course might be checked. The commander then saw in the periscope the mass of the Suffren right in front of him, at a distance of from 35 m. to 40 m. The order to plunge was immediately given, but it was too late to avoid a collision. The shock was tremendous. The men in the submersible were violently thrown about. There was, however, no panic. The safety weights were at once cast loose, and the water ballast tanks emptied. The submersible came to the surface like a bit of cork. It was then found that the stem and the forward water

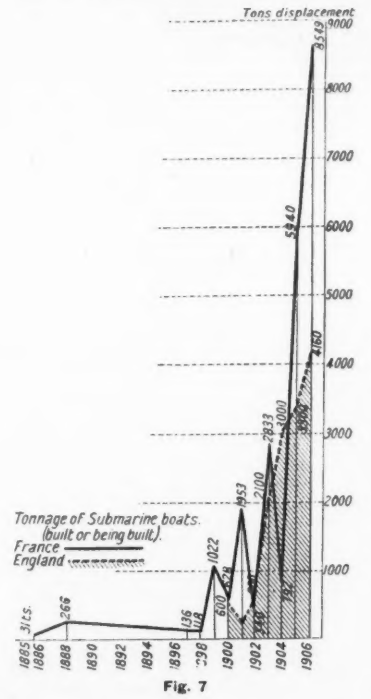


Fig. 7

ballast tanks were crushed in, and that several of her plates were torn. The boat, however, easily got back to Toulon without assistance.

The battleship had a hole ·9 m. by ·40 m. in area torn in a plate on the starboard side below the armoured belt. She immediately made for Toulon, where she had to be dry-docked the next day. The pumps had to be kept going all night. This incident is quoted as showing the strength of the French submarines.

All the submarines actually in service in the French navy are propelled entirely by electricity, and have but a limited radius of action. This is their principal fault. The radius of action of the earlier types only allows of a

FRENCH SUBMARINES AND SUBMERSIBLES

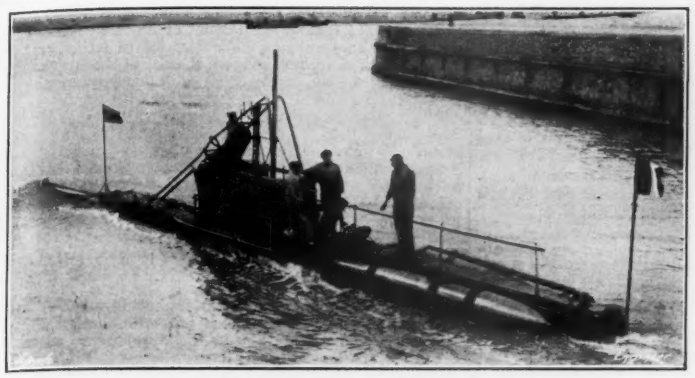


Fig. 8—THE NAIADE TYPE—68 TONS

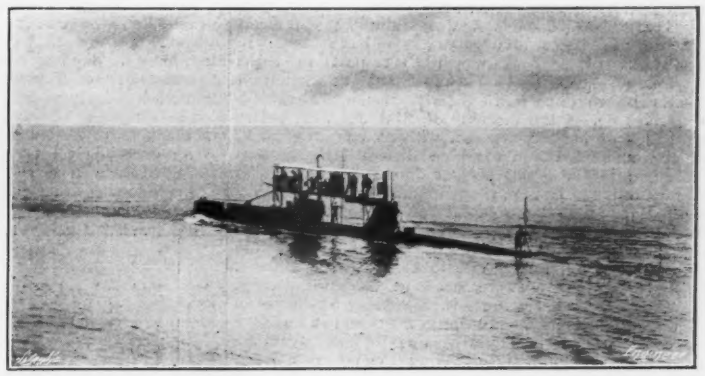


Fig. 9—SUBMARINE Z—202 TONS

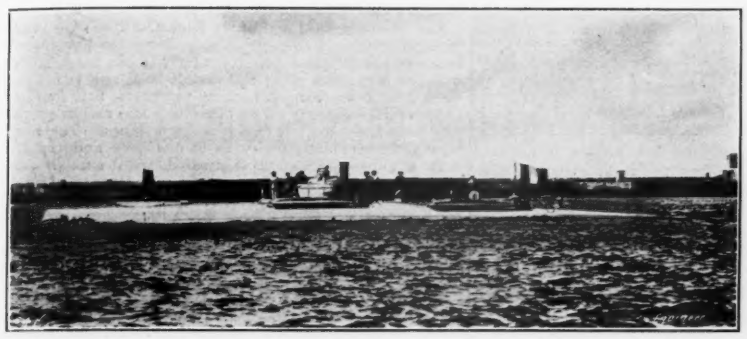


Fig. 10—THE SUBMERSIBLE NARVAL

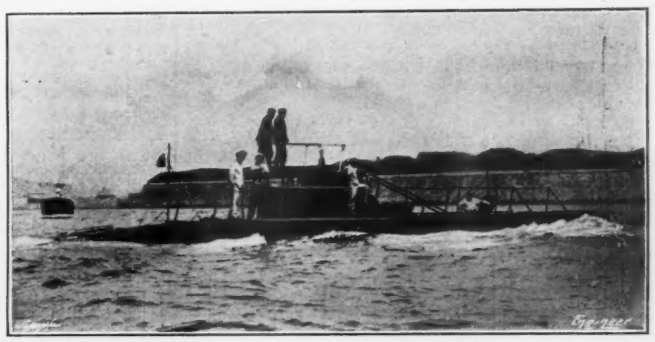


Fig. 11—THE SUBMARINE FRANCAIS

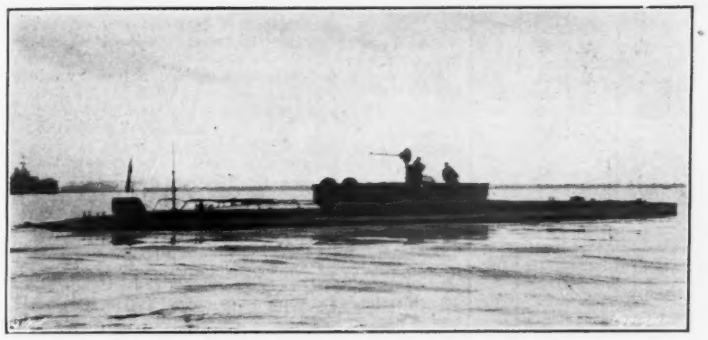


Fig. 12—THE SECOND TYPE OF SUBMERSIBLE

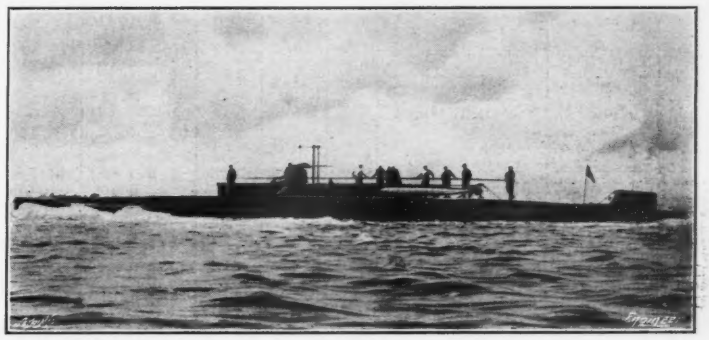


Fig. 13—THE THIRD TYPE OF SUBMERSIBLE

journey of from 30 to 40 miles from the electrical charging station. In addition to this the accumulators are subject to rapid deterioration; they require careful management, take up a lot of space, and are very heavy. All these added together limit the employment of this type of boat. On the return to Marseilles, after the naval manœuvres, following on a severe storm encountered near la Ciotat, the accumulators of the Gustave Zédé suddenly ran down, and the submarine could not move. It had to be towed back to Marseilles by the Utile to recharge its accumulators. This episode does not speak very strongly in favour of the submarine actuated entirely by electricity.

The speed is, as a rule, from 8 to 10 knots, and it is not enough to allow a submarine to reach even a slow ship, unless the latter is moored or unless the former actually finds itself in its course. If the enemy steamed at a quick rate, often changing his direction, a submarine would have the greatest difficulty in reaching him, unless the route had been guessed and the submarine stationed directly in his course.

In order to remedy the slow speed and the limited radius of action, the types most recently launched or being constructed have been considerably modified. The submarine has been made more closely to approximate to the submersible, and in the near future they will only form one class. The submarines of 320 tons displacement will be provided with petrol motors of 600 horse-power, capable of giving them a speed 12 knots.

The submersible is in every way the best arm of submarine defence, whether used by day or by night. It is at will either a submarine or a torpedo boat. The submersible cruises like a torpedo boat and plunges like a submarine at the exact moment when it is necessary to do so. It is ready for action as long as any fuel remains in its tanks. When it is moving at the surface the small target which it offers to the enemy renders it almost invulnerable; it becomes actually so by disappearing beneath the waves, though when it is steaming at the surface it is more visible than the submarine by reason of the smoke which escapes from its funnel, and which might attract an enemy's notice. If it can surprise an enemy before the latter can get up speed, it can approach him with impunity, dive beyond the radius of the automobile torpedo, steer its course by the aid of the periscope, and, when the proper distance away, torpedo him.

The submersible is not tied to any particular port, like a submarine, because petrol can be obtained anywhere. It can travel long distances without having to charge accumulators, and when it is under steam it is ready to plunge. Its battery of accumulators need not be very powerful, for it has, relatively, only a short distance to go under water, and its battery can be charged as the boat is travelling.

If for any reason the submersible is surprised with its accumulators discharged, it promptly sinks and waits for some time until it thinks that the enemy has got tired and gone away. Then it rises in a cautious manner, carefully sweeping the horizon with its periscope. If no enemy is visible, it rises completely to the surface, starts its motor and charges its accumulators as it steams away. The radius of action of a submersible is only limited by the capacity of its fuel tanks. The combustible is, moreover, more easily taken on board than is the case with any torpedo boat.

The French claim that from a defensive point of view the submersibles restore—to a certain point, at any rate—the equilibrium overthrown, to their detriment, by the formidable increases in the English, German, American, and Japanese fleets.

The difference in speed between the submersible and the torpedo boats of the same displacement and exterior form is the consequence of various causes. For example, the weight of the hull of the submersible is much greater than that of the torpedo boat. Having, as it has, to support very high pressures, its scantlings are of heavy section. The weight of the water ballast tanks and of the air reservoirs, the safety weight, &c.—in short, of the necessary apparatus for rising or sinking, is very great. It is evident, therefore, that the weight remaining to be apportioned to the motive power is much reduced as compared with the case of the torpedo boat; and, in addition to this, this weight has to be shared between two kinds of motive power, which take the places of one another, but do not combine their forces. One of these is for motion on the surface, the other for use beneath the sea.

In order to employ it for submarine working the steam engine must be so installed as to be capable of instantaneously getting rid of the gases of combustion or of the fuel employed. This can only be done with the aid of petrol. A short time before the chimney aperture is closed the cocks supplying the liquid to the burners must be closed, and the draught allowed to clear away the products of combustion. Then the chimney may be hermetically closed without any danger.

Although it can be said that the steam engine is much to be preferred on board a submersible to a petrol motor, with steam the consumption can be kept much better within desired limit, while with the petrol motor the consumption is the same whatever the speed is; moreover, explosions resulting from leaks render dangerous the employment of spirit in a confined space where the ventilation necessary to carry off the explosive mixture is practically unobtainable. On the latest types of submersible now under construction, however, petrol motors of 330 horse-power are being installed. These are capable of imparting a speed of 11 knots. The 398-ton boats will each have a steam engine of 700 horse-power, which will give a speed of 12 knots, while the latest types ordered this year are to have a speed of 15 knots.

The Bonite-Suffren incident has suggested to some people a new set of tactics for submarines for small craft against which a torpedo could not be used—namely, an attack by shock. It is thought that with a special form of ram and a careful study of the best conditions of manœuvring to carry out, there might be a good chance of paralysing in a short time a number of destroyers, which, following their ordinary tactics, were defending the armoured vessels against the submarines. On the other hand, the only method to adopt which would seem to give a chance of success to the larger vessels is to build them of high speed. Then quick preconcerted changes must be made in the order of steaming. In such event the slower submarines could only by chance get near enough to attack them.

The cruises of submersibles, and the attacks by submarines, take place so frequently now-a-days in the French navy—at least three times per month—that no more attention is paid to them than to the other manœuvres of the fleet. However at the close of the last naval

manœuvres, Admiral Fournier, in his order of the day, thus expressed himself:—"On the other hand, the operations of coast warfare which have been carried out by the fleet before Algiers, Bizerta, Toulon, and Marseilles, have shown incontestably that the chief arm of defence of ports is the torpedo in all its forms, but especially when used by torpedo boats at night and by submarines by day. The following figures show what ravages the torpedo boats and submarines have made in the ranks of a fleet which took part in these operations:—The fleet had put out of action 5 vessels before Bizerta, 5 before Toulon, 16 before Marseilles during the morning of 31st July, 25 before Marseilles during August 2nd, without counting those which would have been torpedoed before Algiers, where the submarines were not present during the manœuvres of July 6th. It cannot, therefore, be too emphatically insisted upon that the protection of the coast of France in the future will be by a numerous fleet of torpedo boats and submarines covering the ports and the points on the shore most accessible to attack by an enemy. Such a fleet will have even greater effect than shore batteries. At sea the arm to win must incontestably be the vessel of large displacement, but torpedo boats and submarines can destroy a victorious fleet wishing to take advantage of its success by finally attacking the enemy's ports. From this point of view the coast operations of our fleet have profitably taught us lessons which carry us beyond the point where they were left by the English Navy in its brilliant mobilisation manœuvres on the high seas last month. (Signed) Le Vice-Amiral Commandant-en-Chef l'Armée Navale, FOURNIER."

What is to be the future of the submarine? Among French naval authorities it is hoped that in the more or less near future the best defensive arm will be the "submersible destroyer." Such a vessel should have a speed of 20 knots at the surface, and at least 15 knots submerged, as well as a wide radius of action, so as to be able to make cruises of considerable duration on the enemy's coasts, or on the usual courses steered by naval squadrons and commercial fleets. Such a type would not cost much to maintain, and it would be the best protective arm for weak nations, and would enable them to guard their independence and to repulse any invasion or encroachment.

The following statistics regarding the French power in submarines and submersibles are of interest. During the last few years orders to lay down vessels were given as follows:—

October, 1903—Six submarines of the Emeraude type, and of 390 tons.

October, 1904—Two submersibles of the Circe type, and of 350 tons.

August, 1905—Eighteen submersibles, 390 tons.

At the time of writing there are being constructed at the arsenals:—

Cherbourg—Three submarines, Emeraude type, 390 tons; practically completed.

Cherbourg—Two submarines, Guêpe type, 45 tons; time of completion indefinite.

Cherbourg—Two submersibles of 398 tons, to be delivered in June, 1908.

Cherbourg—Ten submersibles of 398 tons, to be delivered in 1908–1909.

Five others are to be ordered. They will be of a larger type, and are to give 15 knots at their trials. They will be finished in 1909–1910.

Rochefort—Three submersibles of 398 tons, to be delivered in 1908.

Rochefort—Five others will be ordered, and will be delivered in 1909–1910.

Toulon—The submersible Omega, launched and being completed.

Toulon—Two submersibles of 398 tons, to be delivered in 1907.

Toulon—Ten submersibles of 15 knots speed are to be ordered for delivery in 1908 to 1910.

The Emeraude—first of her type—was launched some months ago. She is of sufficient size for her crew to live on board as on ordinary torpedo boats or destroyers. Each officer has a separate cabin.

The question of laying down next year eighteen submersibles of 398 tons each, and two of 800 to 900 tons of an experimental type, evolved from study of the vessels actually in service, is being seriously considered.

The following table gives the tonnage of the French submarines and submersibles at present built:—

				Total tons.
1885	1 submarine of 31 tons	—		31
1888	1 ,, 266 ,,	—		266
1897	1 ,, 136 ,,	—		136
1898	—	1 submersible of 116 tons		116
1899	4 ,, 184 ,,	—		—
,,	2 ,, 143 ,,	—		1,022
1900	—	4 ,, 157 ,,		628
1901	20 ,, 68 ,,	—		—
,,	1 ,, 168 ,,	—		—
,,	1 ,, 223 ,,	—		—
,,	1 ,, 202 ,,	—		1,953
1902	—	2 ,, 175 ,,		350
1903	6 ,, 392 ,,	1 ,, 301 ,,		2,653
1904	2 ,, 45 ,,	2 ,, 3·1 ,,		792
1905	—	15 ,, 398 ,,		5,970
1906	—	23 ,, 398 ,,		9,154
		Total		23,071

The two following tables give the names, designers, and principal particulars of the types of submarines and submersibles in the French navy:—

Submarines.

Year.	Name.	Designer.	Number of unities.	Tonnage.	Length.	Breadth.	Draught.	Horse-power.	Method of propulsion.	Number of propellers.	Speed, knots.	Number of torpedoes.	Number of officers.	Number of men.
					ft. in.	ft. in.	ft. in.							
1885	Gymnote ...	Romazotti ...	1	31	55 9	5 10	5 10	95	Electricity	1	8	2	1	8
1888	Gustave-Zédé.	—	1	266	160 0	10 6	10 2	720	,,	1	9	3	2	11
1897	Morse	Romazotti ...	1	136	118 1	9 0	4 8	360	,,	2	12	3	2	8
1899	Français ...	,, ...	2	143	118 1	9 2	9 0	360	,,	2	13	3	1	8
,,	Farfadet ...	Maugas	4	184	135 6	9 6	9 2	280	,,	1	12	4	1	8
1901	Naiade	Romazotti ...	20	68	76 1	7 5	8 8	60	,,	1	8	2	1	4
,,	X	,, ...	1	168	122 8	10 2	7 6	220	Petrol and electricity	1	8	5	1	4
,,	Y	,, ...	1	213	142 2	9 10	7 8	250	,,	2	11	4	—	—
,,	Z	Maugas	1	202	135 6	9 10	9 10	190	Petrol	2	12	4	—	—
1903	Emeraude ...	,,	6	390	145 5	12 9	12 0	600	Petrol and electricity	2	12	6	2	19
1904	Guêpe	Petit Homme...	2	45	66 4	6 10	6 7	240	Electricity	1	10	2	1	6
,,	Goubet II. ...	—	—	10	26 3	8 8	—	—	—	2	—	2	—	—

Submersibles.

1898	Narval	Laubeuf	1	116	111 7	12 3	5 2	250	Steam and electricity	1	13	4	2	8
1900	Sirene	,, ...	4	157	110 6	11 3	5 2	217	,,	1	12	4	2	8
1902	Aigrette ...	,, ...	2	175	117 8	12 9	8 3	200	Petrol and electricity	2	11	4	2	9
1903	Omega	Bertin	1	301	160 5	13 8	9 0	330	Petrol	1	11	4	2	17
1904	Circe	Laubeuf	2	351	154 6	16 0	10 2	440	Steam and electricity	2	11	7	2	20
1905	Q 51 to 66 ...	,, ...	15	398	167 8	16 2	10 3	700	,,	2	12	7	2	22
1906	Q 67 to 69 ...	,, ...	3	398	167 8	16 2	10 3	700	,,	2	12	7	2	22
,,	Q 70 to 89 ...	—	20	—	Details	still unknown		—	—	—	15	—	—	—

The Aigrette and her type are considered the best submersibles now in service. In spite of their only having a displacement of 175 tons, their fuel capacity enables them to run twice from Cherbourg to Portsmouth and back without bunkering, and so they are able to make a cruise along the English coast. The Cigogne, the second of this type, is fitted with a Diesel motor. Her full speed afloat is 12 knots, and she has 5000 litres of paraffin in her bunkers, so that she can run for 70 hours at a fair speed. The Diesel motor, however, has not proved itself wholly suitable for the purpose.

The various engravings given in Figs. 1 to 5 and 8 to 13 show various types of submarines and submersibles, and the reader will be able to obtain particulars of them from the foregoing tables. The two diagrams, Fig. 6 and Fig. 7, set out some interesting facts about the growth of tonnage in England and in France of these types of fighting ships.

AMERICAN TRAMWAY ASSOCIATION.

THE first annual meeting of the American Tramway Association since its reorganisation indicates that the association has benefited materially by the change. It was originally the American Street Railway Association, and with the modern development of the tramway business part of its energies had been taken away by the formation of special associations of tramway engineers, mechanical superintendents, accountants, &c. Under the reorganisation the main association was named the American Street and Interurban Railway Association, and the others were affiliated with it as independent sections dealing with different branches of membership and work.

At the meeting of the engineering section it was stated that there is a tendency to equip electric cars with the multiple-unit system of control on account of its many advantages, even where cars are not to be operated in trains, and the manufacturers have now reduced the size of the apparatus so that it can readily be placed on an ordinary tramcar. The apparatus is under the car, dispensing with the use of the ordinary platform controller. A paper on "Permanent Way Construction," by Mr. C. H. Clark, referred to a number of systems in which steel sleepers are used in combination with a concrete foundation bed. The discussion showed that many lines prefer wooden sleepers embedded in concrete, while others prefer broken stone ballast in place of concrete; for interurban or country lines stone or gravel ballast is commonly preferred to concrete. As to grooved rails, there are very few designs now made that are adapted properly and economically to take the ordinary size and shape of wheel flange; it was suggested that the tramway engineers, rail makers, and wheel makers ought to meet together to determine the proper relative forms of rails and wheels. A paper on "Sleepers and Poles," by Mr. C. A. Alderman, advocated the use of creosoted sleepers if wood is used, but attention was called to the possibilities of concrete and steel sleepers. Concrete posts for the overhead wires have been tried, but as a rule steel poles are used in cities and wooden poles in the country. It was suggested that as creosoted poles are better conductors, it would be well to treat only the lower part instead of the entire length of the pole.

Mr. Windsor, of the Boston Elevated Railway, read a paper describing two power plants driven by gas engines; both are of small size, being auxiliary to the main station, and the capacities being 700 and 1000 kilowatts. One of these has down-draught suction producers, and four-cycle single-acting engines. The other has up-draught pressure producers and two-cycle double-acting engines. The results have been very satisfactory as to efficiency and economy, both intrinsically and as compared with similar steam plants. At Elmira a Crosby four-cylinder gas engine of 1400 horse-power has successfully operated three-phase 60-cycle apparatus.

Mr. H. G. Stott followed with a paper on "Underground Cables for Power Transmission," and then a paper on "The Relative Economy of Steam Turbines and Reciprocating Engines at Various Percentages of Rating," by Mr. Wallis Goodenough, was presented, making a favourable showing for steam turbines under proper conditions. A paper by Mr. E. H. Anderson dealt with the scientific relation of the equipment and weight of electric cars to their running schedules, so as to ensure economy and efficiency of working, and a good service for the benefit of the public. One great trouble, it appears, is in the selection of the proper gear ratio. Mr. H. M. Brinckerhoff gave an interesting paper on "The Elevated Electric Railways of New York, Chicago, Boston, and Brooklyn."

With regard to electric interurban or country railways, Mr. E. C. Spring dealt with the operation of goods and express service on lines affording good traffic; while Mr. E. P. Roberts described the proper methods of promotion, construction, equipment, and operation for "light" electric railways in thinly populated districts. The report of the Committee on Heavy Electric Traction stated that on many electric railways the weight of rolling stock, the capacity of the plant and the operating speeds are as great as or greater than, on steam railways. These lines include elevated and underground lines in the large cities, and also many interurban lines. The mileage of steam railways converted to electric traction is as yet comparatively small, but the electrification of several lines entering New York is well under way, and the projected electrification of other roads there and in other sections of the country gives promise that a large amount of this class of work may be expected in the near future. It would be difficult to draw a dividing line between the ordinary trolley line tramway and what may be called a "heavy electric traction" line, and it is evident that the interests of heavy interurban electric lines and electrified steam lines are going to be very closely identified in the future, so that the association must be prepared to deal with both tramways and railways.

A number of other papers was presented, but they dealt mainly with questions of operation, discipline, fares, and tickets, employés, &c., and were not of direct engineering interest. The Association of Manufacturers had arranged an immense exhibit of tramway equipment, supplies, and appliances.

ROYAL INSTITUTION OF GREAT BRITAIN.—A Christmas course of experimentally illustrated lectures, adapted to a juvenile auditory, on "Signalling to a Distance, from Primitive Man to Radiotelegraphy," will be given by Mr. W. Duddell. Lecture 1, Thursday, December 27th, 1906; Lecture 2, Saturday, December 29th; Lecture 3, Tuesday, January 1st, 1907; Lecture 4, Thursday, January 3rd; Lecture 5, Saturday, January 5th; Lecture 6, Tuesday, January 8. Lecture hour, three o'clock.

GREAT EASTERN RAILWAY.—The third annual reunion dinner of the past and present staff of the locomotive department of the Great Eastern Railway at Stratford was held in the Abercorn Rooms of the Liverpool-street Hotel, London, on Friday, December 7th, when a company numbering nearly ninety sat down to dinner, under the presidency of Mr. Wm. H. Maw, past-president of the Institution of Mechanical Engineers. A very enjoyable evening was spent under the presidency of the chairman, who, before the meeting concluded with "Auld Lang Syne," proposed a vote of thanks to the Committee—Messrs. James Holden, chairman; Godfrey Elliott, A. J. Hill, J. W. Howard, W. F. Pettigrew, A. W. Polley, and F. V. Russell—to which Mr. A. W. Polley replied.

CUXHAVEN: A NAVAL BASE.—The little port of Cuxhaven, which lies at the mouth of the Elbe and at a distance of 58 miles W.N.W. of Hamburg, is in process of becoming the second great naval base on the North Sea. During the last two years the garrison has been quadrupled, and its fortifications are now completed, for the German Ministry of Marine has resolved to make Cuxhaven a first-class port to defend Hamburg from an enemy's ships. Even now it is maintained that the big guns now mounted at Cuxhaven are sufficient to prevent a British squadron from entering the mouth of the Elbe. However, the fortifications and defences are to be increased, and the new big guns, which are to be put into position shortly, are to be capable of destroying from Cuxhaven any fleet that may venture in the neighbourhood of Cuxhaven. In addition, the port of Cuxhaven is to be enlarged and deepened considerably, so that all the biggest vessels of the German navy may ride at anchor in it.

RAILWAY MATTERS.

THE *Bulletin Commercial* states that the Dutch Parliament has voted a subsidy for the construction of a railway in Haarlemmermeer, the district lying between Amsterdam and Haarlem.

THE new railway between Perm and Yekaterinenburg is to be opened next year, and the local mine owners are establishing telephonic communication between both those important centres of the mining industry.

IT is reported that an agreement for the purchase of the Central Railway by the State of Mexico has been signed on behalf of the Government and the administration of the railway. The line will be amalgamated with the National Railway.

IT is reported that several days ago negotiations were begun, and are on the point of being concluded, if they have not already reached a conclusion, between the British Government and the Congo Free State for the concession to Great Britain of a strip of territory for the Cape to Cairo Railway.

AS a result of practical tests which have been in operation in Sweden, with a view to electrifying the whole of the railway system of the country, the Government are building at the Falls of Gullspang a large electricity station, capable of producing not less than 150,000 horse-power. It is expected to result in reducing by 1,500,000 kroner annually the consumption of British and other coal.

THE new line of tramways which the London County Council has laid along the Thames Embankment and over Westminster Bridge was opened to the public on Saturday last. Although it seems to work satisfactorily so far, much inconvenience is caused to other vehicular traffic at the foot of the bridge on the Lambeth side by the crossing of lines from the centre to the side of the roadway.

AMERICAN electric railways, including city tramways and elevated and inter-urban or country lines, at the close of 1905 had a total length of 32,517 miles, with an equipment of 76,450 cars, of which 63,390 were motor cars. Steam, cable, and horse tramways had only 333 miles, and at the present time cable lines are almost obsolete. The total capital of all tramways and electric railways was £370,000,000.

THE *Feuille Fédérale Suisse* of 28th November contains a copy of a concession granted to M. Romain Avanzini, engineer, of Lausanne, and M. Eugène Nyauld, manufacturer, of Hermance, for the construction of a *Crémaillère* railway—steam or electric traction—from St. Gingolph to Grammont, and eventually to the Cornettes de Bise. The cost of the work is estimated at about £146,000, of which about £8160 is to be expended on rolling stock.

ACCORDING to a Paris newspaper, a competent authority estimates that the yearly cost to the railroads of France of giving their workmen a day off each week will be from £1,200,000 to £1,600,000. It will be remembered that the Sunday rest law, recently passed, exempted the railroads from its provisions, the intention being apparently, to take up the needs of railroad workmen at a later time; but the railroads conferred with each other and agreed to grant the seventh day rest voluntarily.

THE Special Commission which went out to survey the route for a line of railway to connect the Russian railway system of Turkestan with the Siberian Railway has returned to St. Petersburg. It reports that the projected connection between the two important railway systems is an absolute necessity "in the interests of the economical development of the region that will be traversed by the new railway." Needless to say, the strategic importance of the line has been the main consideration in surveying it.

STARTING with the Interstate Commerce Commission's figure of £31,800,000 as the fuel bill for all the railways in the United States in 1904, the *Railway Age* estimates an average cost of 6s. a ton, giving a total consumption of 106 million tons. The number of locomotives owned by railroads in the year 1904 was 46,885, and assuming 8 per cent. of these to be in the shop under repairs, there remain 37,508 engines in service, and this number divided into 106 million tons gives 2826 tons as the average consumption of coal per engine year.

A BILL was on Monday last deposited in Parliament to incorporate the Channel Tunnel Company, and to authorise the construction of works which shall form part of the schems intended to connect England and France by means of a railway in tunnel under the English Channel. It is estimated that the scheme will involve a total outlay of £16,000,000. Two parallel tunnels will be constructed, the total length under the sea being 24 miles, and with the land approaches on either side 30 miles. The traffic will be worked electrically.

THE railways of Chicago, U.S.A., twenty-five in number, have a traffic of 1537 trains arriving and departing daily. These include 458 main-line passenger trains, 807 suburban trains, and 272 goods trains. The 1265 passenger trains are distributed between six terminal stations. The largest number of main line trains is handled by the Chicago and North-Western Railway, which has 78 passenger and 58 goods trains daily. The largest number of suburban trains is 251. on the Illinois Central Railway, as against 220 on the Chicago and North-Western Railway.

THE Siberian Railway and its continuation, the Trans-Baikal Railway, have succeeded in establishing a most unenviable record this year, as never hitherto have there been so many cases of theft and robbery of freight in transit. The goods department of the latter railway is overwhelmed by inquiries as to stolen freight of all kinds. During the eleven months of this year no fewer than 3000 cases of theft have been reported on the Trans-Baikal Railway, as compared with 1700 cases last year. One of the stations most notorious for the number of thefts occurring at it is known among the traders, who have suffered from its methods, as "The Freight Churchyard."

AT every distance of one verst, or two-thirds of a mile, along every Russian railway there is a bell, which is connected with the others by an electric wire. These bells, or gongs, were put up for the purpose of giving two signals of distress in winter; one signal was that of "snowed up," and the other was "help, help." During the summer this signalling apparatus has not been used much, and now they are to give only one signal, namely, "burglars." When this signal is given, owing to the many attacks being made on Russian railways and railway stations, the nearest telegraph office has to give the alarm to the two nearest stations so that for a distance of a few miles the entire neighbourhood can be surrounded by troops and local policemen.

THE chief goods manager of the North-Eastern Railway, Mr. W. Robinson, will retire at the end of the year after having completed over forty years' active railway service. Mr. Robinson commenced his business career at Malton Station as a junior goods clerk, and, after serving in different capacities at various centres, he was, about the year 1866, appointed chief of the rates department of the goods manager's office at York. Some fifteen years ago Mr. Robinson was appointed to the head of the rates and fares department, retaining that position until his appointment, towards the end of 1900, as chief goods manager, in succession to the late Mr. Charles Jesper. Mr. Robinson will be succeeded by Mr. E. C. Geddes, the present deputy-goods manager and commercial agent of the North-Eastern Railway at York.

NOTES AND MEMORANDA.

IT is estimated that 75 per cent. of the world's copper is obtained from sulphide ores.

THE production of copper in the United States during 1905 reached the enormous figure of 402,637 tons.

THE cost of refining a ton of crude copper by electrolysis varies greatly, ranging from about £2 up to probably nearly £5, but the average cost is likely to be about 48s. to 56s.

A NEW commercial harbour is to be made near Bremen, estimated to cost 20,000,000 marks, and the Senate has already voted a credit of more than half that sum for the purpose. It is proposed to place it on the right bank of the Weser, and adjacent to the second free harbour.

A STUDY of economic geology shows that the deposits of both lead and zinc ore, whether in association or alone, form most readily in connection with a dolomite or limestone country rock. Most of the great lead and zinc ore deposits of the world occur in formations of those rocks.

THE German Technical High School at Prague celebrated on November 10th the centenary of its foundation. It was the first technical school which was not of a military character to be founded in Europe. During the first year of its existence, when the instruction was free, there were 106 students, and now there are about 1000 students attending its various classes.

A LONDON County Council Committee reports that the smoke of large towns like London and Manchester have a deteriorating effect upon the people's physique. The smoke-laden atmosphere diminishes the vitality of those who habitually breathe it, and shortens their lives. The genius of the members of the Committee was scarcely required to point out this obvious fact.

THE earliest sub-aqueous aqueduct tunnels in America, says *Cassiers' Magazine*, were those built at Chicago in 1864-67, two miles long, at a cost of 457,844 dols., and subsequently extended four miles further for a fresh water supply. A second conduit, 8ft. in diameter, and four miles long, was added in 1887-1892, and also at Cleveland in 1869-74, when a conduit 5ft. in diameter and 6606ft. long was built.

OVER 500,000,000 gallons of water are pumped out of the anthracite coal mines of Pennsylvania every day in the year. The exact average for 1905 was 633,000,000 gallons a day. Nearly 1000 powerful engines, delivering from mine bottom to surface 500,000 gallons of water a minute, are required. Mines may be shut down and coal production suspended, but the water flows on for ever. According to the *Iron Age*, the cost of removing it is one of the important items of expense that make up the price of anthracite.

ACCORDING to the returns of vessels totally lost, condemned, &c., compiled by Lloyd's Register, 139 steamers and sailing ships, of 121,542 tons, were totally lost, condemned, &c., in the three months ending 30th June. Germany stood at the bottom with a percentage loss of 0·11 per cent., the United Kingdom coming next with 0·28 per cent., Russia was at the top with a percentage of 1·26 per cent., and Italy next with 0·74 per cent. Of the 121,542 tons lost, 71,880 tons were wrecked, and 16,716 tons were lost by collision.

SHIPBUILDING in the United States is a growing industry, in spite of the discouragement to which shipbuilders are subjected, says the *Iron Age*. In a recent census bulletin it is shown that although the number of establishments engaged in this industry has decreased since 1880 from 2188 to 1097 in 1904, the total capital invested has increased during this period from £4,196,000 to £24,324,800, or 480 per cent. The number of workpeople has increased from 21,345 to 53,234, or 149 per cent., and the employés per yard from 10 to 48, or 380 per cent.

ACCORDING to the *Engineering Record*, the fuel consumption of two 120 horse-power Diesel oil engines at Effingham, Ill., each direct-connected to two 60-cycle, 2200-volt, 85-kilowatt alternating-current generators, was stated by Mr. W. G. Austin, before the Illinois State Electric Association, to be 15½ gallons of crude oil for a 24-hour run, the load averaging 23 per cent. of full load. Oil costing 3·4 cents per gallon was used, making cost of operation 0·542 cent per kilowatt-hour. With a 30 per cent. load the fuel cost decreased to 0·485 cent per kilowatt-hour, while on a six-hour test, with a 70 per cent. load, it was reduced to 0·384 cent per kilowatt-hour.

AN electric filter, the invention of a Hungarian engineer, is about to be exhibited in St. Petersburg. The filter is in two parts, and is of very simple construction. One part is connected with an electric circuit, which sends a powerful current through the drinking water and thereby kills at once any micro-organisms in it, the second part is an ordinary filter of an improved type. This new filter is to be tested in the St. Petersburg hospitals and laboratories. So long as the Russian capital sees fit to discharge its sewage into the Neva, and so long as the people will persist in using the water of that river for making tea, there will be a splendid chance for somebody to make his fortune and at the same time to reduce the death-rate of the Russian capital by inventing a really reliable filter.

DURING the discussion of M. Girod's paper on making alloys by electro-metallurgy before the French Civil Engineers' Society, M. Guillet observed that it raised two important questions—the making of ferro-metallic alloys and the preparation of steel by the electric furnace. In connection with the former, he urged the advisability of keeping the carbon contents low, because, in making special steels for mechanical construction, the tendency is increasing to prepare alloys but very slightly carburetted, and also because certain carbides—especially those of vanadium, borium, and tantalium—are insoluble in the bath of molten steel. There is, consequently, in such case, a portion of the metal which is not utilised, and, besides, the carbon remaining interposed in the steel would induce fragility.

BOTH in steamers and sailing vessels the German mercantile marine continues to show a satisfactory increase. Germany now owns 1350 steamers and about 1000 large sailing ships. According to some statistics compiled lately, it appears that while England's steam shipping increased by half a million tons during the past twelve months, that of Germany increased by 225,000 tons. The German sailing vessels were the only vessels of that type to show an increase, as nearly all the other nations connected with shipping show a decrease. Thus, the English sailing ships fell off to the amount of 105,000 tons, and those of the United States by 14,000 tons. France and Russia show no change; Norway's sailing ships increased by 2 per cent.; the highest increase was that of Germany with 5 per cent.

THE net annual receipts of the Paris Metropolitan Railways have increased from 130,580f. per kilometre, or £8357 3s. per mile; in 1901, with 13 kiloms. = 8 miles worked, to 200,104f. per kilometre, or £12,806 13s. per mile; in 1904, with double that length worked, and 202,927f. per kilometre, or £12,987 4s. per mile; in 1905, with 32 kiloms. = 20 miles. The opening, in May last, of the South circular line, on the left bank of the Seine, and connections with the Lyons and Orleans termini, brought up the length worked to about 41 kiloms = 25 miles, completing what is called the first *réseau*. It was feared that the traffic on the South circular line would fall far short of that on the others, so as to greatly reduce the general mean; and accordingly the dividend distributed to shareholders was reduced as a precautionary measure, so as to increase thr reserve in hand.

MISCELLANEA.

SEVERAL London motor omnibus companies are experimenting with the use of paraffin carburetters.

THE Mars battleship has established a record for the port in coaling at Portsmouth. Lying alongside the coat depôt she shipped 1240 tons in four hours five minutes.

THE *Boletim Official* of Mozambique of 3rd December contains a copy of a decree assigning a site on the banks of the river Umbelusi to the Municipality of Lourenço Marques for the erection of pumping machinery for supplying that town with water.

THE British Vice-Consul at Rouen reports that tenders will be opened on the 9th January, 1907, at the Préfecture of Rouen, Department of the Seine Inférieure, for the construction of a metal swing bridge in the Port of Havre. The maximum price is placed at £5960.

THERE would be a good market at Christiansand for engines for fishing boats, pilot steamers, and small cargo boats. The engines sold so far have been imported from America. As very few engines are made in Norway itself, the trade is one which offers a good prospect for exporters to Norway.

AMERICA will, next month, have its first exhibition of devices for safeguarding the lives and limbs of working men and women, and for preventing accidents under the ordinary conditions of life and labour to which the general public is exposed. The exhibition will be held at New York, under the auspices of the American Institute of Social Service.

THE estimated loss on the London County Council's steamboat service for the year ended March 31st next is £37,416. The Rivers Committee, who have controlled the steamers since the inauguration of the service, have prepared a report, in which they suggest that the control should be transferred from them to the Highways Committee, who already have the management of the tramways.

THE most notable outcome of the Trade Marks Act, 1905, is the registration of a trade mark for goods of Irish manufacture. The design, says the *Ironmonger*, consists of the reproduction of an old Irish ornament, together with the words "D'lanta I Eirinn" ("Made in Ireland"). The idea is, of course, to ensure that only those articles which are really of Irish manufacture shall be sold as such.

REPLYING to a question asked in the House of Commons, Mr. Lloyd-George said it has been arranged that the Board of Trade shall co-operate with the Foreign-office from the beginning of next year in the editing of the annual consular reports. Every effort will be made to expedite their issue. Consular officials have been instructed to report at once—using the telegraph where necessary—any matters of immediate commercial importance.

A MOTOR Car Exhibition will be held in Calcutta from January 28th to February 6th, under the auspices of the Automobile Association of Bengal—Mr. J. H. H. Rolfe, secretary, 57, Park-street, Bengal, India. The charge for each car exhibited will be 160 rupees, and for accessories, tires, &c., the charge is 160 rupees for each 200 square feet. The allotment of space will be by ballot, but it is stated in the preliminary rules on what date entries for the ballot close.

THE new bridge across the St. Lawrence River, near Quebec, is 2800ft. long between centres of anchorages and will have a total width of 82ft., including the cantilever foot paths. It is designed to carry two railroad tracks, two highways, and two electric car tracks on a single deck about 200ft. high above extreme low water. The 1800ft. cantilever span across the channel is flanked by two 500ft. anchor arm spans, each of which weighs about 12,500,000 lb., exclusive of about 1,400,000 lb. for its portion of the floor system.

H.M. CHARGE D'AFFAIRES at Bangkok has forwarded a copy of an agreement the Siamese Government have made with a British concessionaire by which the latter is granted the exclusive right, for not more than twenty-five years, to dredge for tin ore in the whole of the area known as Puket Harbour, in exchange for his undertaking to excavate a dock 1200ft. by 850ft., with a depth of 20ft. at low-water spring tide within the harbour, and to excavate a channel to it, as well as to maintain the same for the term of the concession.

AN International Motor Boat Exhibition is to be held at Kiel next year, from the 15th to the 30th of June, under the patronage of his Royal Highness Prince Henry of Prussia, and supported by the Imperial Navy, the German Sea Fisheries Union, and other bodies. The Imperial Navy has placed at disposal for the exhibition a piece of ground finely situated on the harbour. Information may be obtained from Baron von Moltke, the business manager of the exhibition in Kiel. This matter is one of much importance, for not only has it a significance for our own industry and that of Germany, but it nearly concerns all people employing motor boats.

THE Commission appointed by the municipality of Paris to visit the district of the Lake of Geneva and the Rhone in order to study the vast project for the transport of the power of the river to Paris is now at Geneva. The great undertaking of this project would be the construction of a barrage at Seyssel (Ain), 230ft. high, the highest in the world, surpassing the height of Niagara Falls by about 66ft. The force created by this immense fall would be utilised by large generating works at the foot of the barrage, and transmitted to Paris by electric cables. It is calculated that the realisation of this project, costing about 60 millions of francs, would save the municipality of Paris about 20 million francs yearly.

THE manufacture of bronze fittings for buildings is, says the *American Metal Market*, an industry which has doubled within three years, and is increasing in a ratio perhaps greater than that of other branches of the copper-consuming trade, "owing to the enormous amounts of bronze trimmings specified by architects in the form of decorative interior work." Thus the new Hall of Records in New York City has 62,000 lb. of copper in its dome, and the building contains copper in all forms to the amount of 600,000 lb. Three office buildings under construction in the financial district of New York City will require in the aggregate 2,450,000 lb. of copper within a year, in the forms of wire, window sheathing, roofing, leaders, and bronze and brass fittings.

WHAT good results have attended Russia's efforts to grow cotton in Central Asia is seen in the recent returns with regard to the output. The returns show that the region referred to produces 160,000 tons of cotton out of the total of 270,000 tons required by the Russian manufacturers. Of that total of 160,000 tons the Fergana Territory produces 90,000 tons, the Syr-Darya region produces 8000 tons, Samarcand and Trans-Caspia produce 13,000 tons, the Trans-Caucasus 16,000 tons; while in Khiva, Bokhara, and the Persian borderland produce altogether 32,000 tons. It has now been proved that cotton can be cultivated still more, and without unduly costly irrigation. Three cotton-growers leased a tract of waste land lying on the Tedjen River, put up an oil engine and pumped up water over the fields several hundreds of acres in extent; on this land cotton was then planted, and the crop came out at nearly two tons per acre. Next year these enterprising cotton-growers intend to set up stronger machinery for watering the land, when they will plant 2400 acres with cotton.

DEVELOPMENT OF THE WALSCHAERT'S VALVE GEAR

(For description see page 620.)

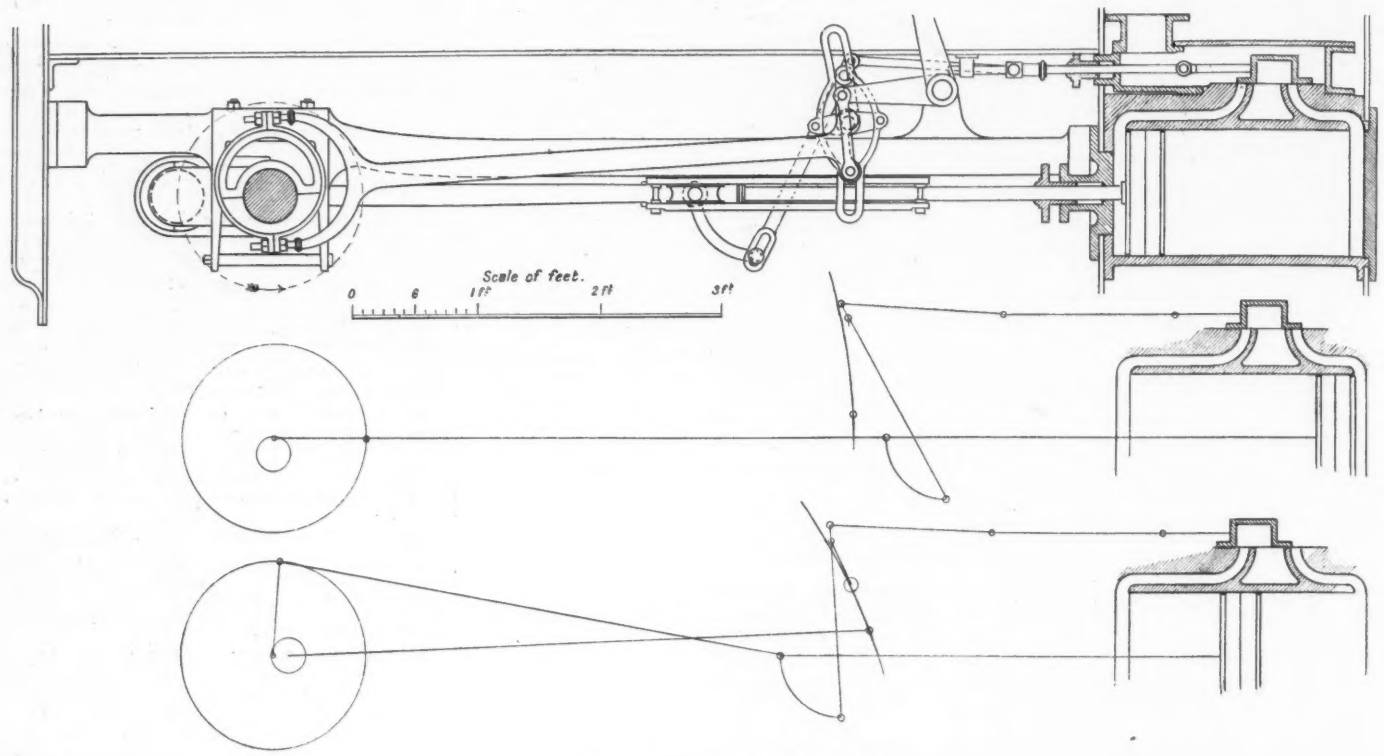


Fig. 2—WALSCHAERT'S VALVE GEAR OF 1844

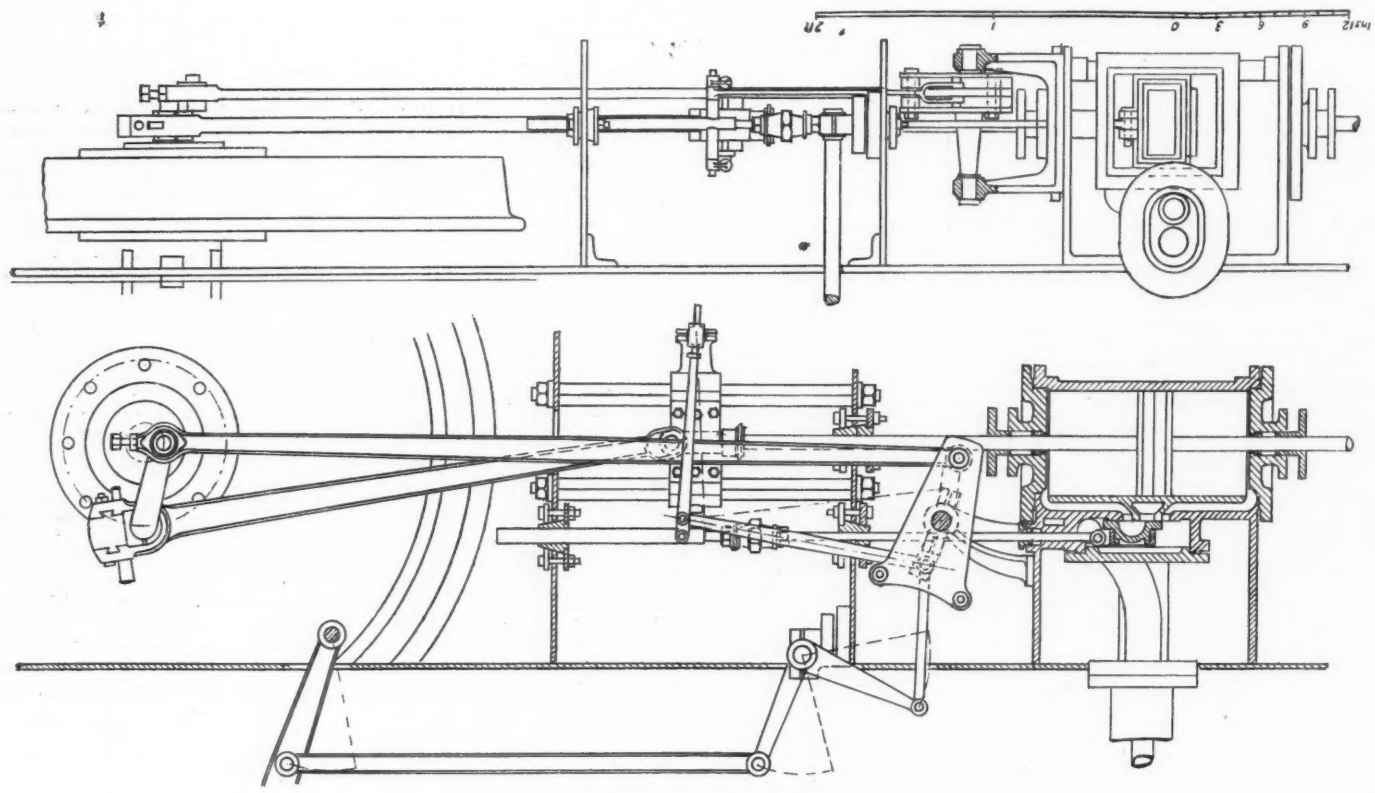


Fig. 3—WALSCHAERT'S VALVE GEAR OF 1848

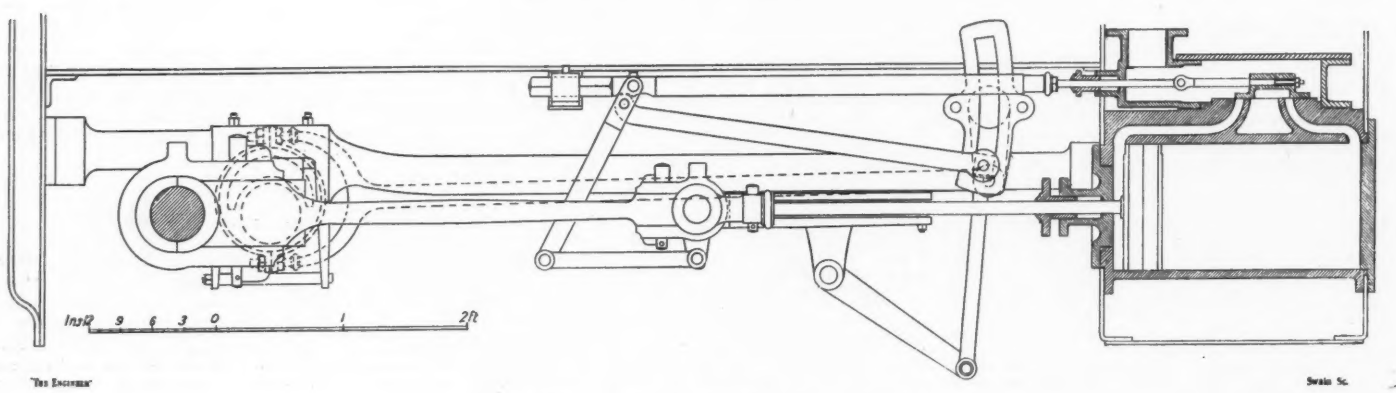


Fig. 4—HEUSINGER VON WALDEGG'S VALVE GEAR

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Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

W. E. B. (Rugby).—See "Railway Carriages and Wagons: Their Design and Construction," by Sidney Stone.

J. F. F. (Glasgow).—Try the *Canadian Engineer* and the *Canadian Electrical News*, both published in Toronto.

J. W. (Ashton).—You might see the "World's Locomotives," by C. S. Lake, published by Percival Marshall, or "La Locomotive Actuelle," by Demoulin, published by Beranger, of Paris.

T. D. (Pendleton).—If your model works, look for some defect in the arrangement. In a case of this kind the model is more likely to be wrong than the theory. Send us an exact description of the model, neglecting no even apparently unimportant detail.

J. K. (Farnham).—We believe the Tantalum lamp has no more injurious effect on the eyes than other lamps. The other cause you give is probably the correct one, but you have probably been reading with a brighter light than usual. Try an opaque shade to shield the eyes.

J. W. H.—We cannot recall the name of any work devoted to the creosoting of timber, but brief descriptions of the methods followed may be found in various places. The Haskin process of preserving timber was illustrated and fully described in THE ENGINEER of January 28th, 1898.

WORKER.—Draughtsmanship may be learnt at any age. It is not a profitable occupation. There is no profession in which you may not be "little more than a machine" if you have it in you to be otherwise. As you have started in the clerical line, we should say continue in it. It gives as many opportunities as other branches of commercial engineering. The articles on "Commercial Organisation" began in our issue of March 3rd last.

THE ENGINEER.

DECEMBER 21, 1906.

The Grantham Accident.

LAST week we placed before our readers the substance of Lieut.-Colonel von Donop's report on the Grantham accident. It is much to be regretted that this must be added to an already too long list of unexplained and, we presume, inexplicable catastrophes. The principal value of an explanation of this kind is that it supplies information which may be utilised to prevent the recurrence of an undesirable event. The satisfaction of mere curiosity is quite a secondary matter. In the present case we have two problems to consider. The first is why the train did not stop at Grantham; the second is why it left the line. As to the first no satisfactory answer is forthcoming. It may be worth while, however, to place on record a theory held by several enginemen. They believe that Fleetwood, the unfortunate driver, was dead on his seat before the train reached Grantham, and that Talbot, the fireman, knew nothing of the fact, and took no action until it was too late. There is nothing impossible about the matter, sudden death from heart disease being deplorably common. A post-mortem would probably have settled the point. There will be general agreement with Colonel von Donop's remark that it ought to be a rigid rule that a driver who leaves his work through any form of sickness should pass the doctor before he returns to his responsible duties. It is, however, in this case, quite possible that, as we have suggested, the driver might for a moment lose himself, just as a bicycle rider, or the driver of a motor car, may turn his steering handle the wrong way, and so bring about disaster. Those lacking footplate experience hardly ever realise how brief is the time required to pass from safety to disaster, how short the period in which a man must make up his mind. If the train ran through Grantham Station at 60 miles an hour, which there is some reason for supposing, the time occupied would be only 12½ seconds, the platform length being 275 yards. At a distance of 135 yards further on the train would encounter the facing points, the time of traverse being only 6 seconds. The total length of the two reversing curves and the straight is 330ft., which might be traversed in five seconds, the total time occupied between entering Grantham Station and the derailment being little more than one-third of a minute—not a long period in which to rectify a mistake. Even if the speed had been but 40 miles an hour, about half a minute only would be available. The catastrophe, indeed, would almost resemble the work of lightning in its suddenness. It is, however, useless to refer further to the driver and fireman; the details of the derailment present more interest.

So far as we can gather, the engine got round the curve all right; the trailing wheels of the tender left the road. The tank then struck the parapet of a bridge, and threw it down. Lastly, it dragged the trailing end of the engine off the line. The engine upset, and the tender fell down the embankment. Why did the tender leave the rails? The first answer that occurs is that it was derailed by centrifugal effort, but this is by no means certain. The engine rounded the curve safely. It is true that there was no superelevation worth naming, simply because the maximum speed contemplated for trains traversing the curve was 15 miles an hour. The facts are not complicated by an overturning; the centrifugal effort was not sufficient for that. Colonel von Donop is disposed to think that a bogie engine with four-coupled driving wheels could get round, while a six-wheeled tender with a longer rigid wheel base could not. But this is not quite clear. Sharp curves are always laid to a wider gauge, sometimes as much as an inch wider, than the normal, to accommodate six-wheeled vehicles. Again, the probability was that the central flanges on the tender had been thinned down. No one supposes that the wheel base of the tender was so long that it could not get round the curve at 15 miles an hour. It is to us evident that the tender was subjected to more stresses than one. There was centrifugal effort, which would be about nine times as great at 45 miles an hour as at 15 miles an hour; and there would be the stress due to the tying of the engine to the tender by the draw-bar under the footplate and the two spring buffers—that is to say, an effort was needed to bend the engine and tender as a whole at the joint between them. The resistance to this effort would tend to force the trailing wheels of the tender outwards, and would supplement the centrifugal action. Every train which has buffers outside the central line, possesses lateral stiffness when the draw-bars are screwed up. It tends to straighten itself horizontally, and it is matter of common knowledge that much of the extra resistance of trains on curves is entirely the result of buffer action. In this way we can frame a hypothesis which will help to explain how it came to pass that the tender got off the line. We do not argue that central buffers are the best, or that draw-bars should not be screwed up. The balance of advantage is entirely with the existing system. As to the actual sequence of events after the tender left the rails, there is no positive information available. The only thing at all certain seems to be that if the tender had kept on the rails there would have been no catastrophe. Incidentally we may ask whether it might not be worth while always to fit tenders with central axle-boxes having play in the horn-plates. It does not appear that any traverse springs would be required, as the freedom permitted would be too small to mean any risk in taking points or crossings.

The fires that followed the accident were alarming events. Colonel von Donop urges that as one of them was due to gas, gas ought not to be used as a railway illuminant. But one of the conflagrations was caused by the engine fire, and it is not at all certain that the use of electricity would secure immunity. Indeed, electricity may introduce risks of its own which are quite as serious as those brought about by gas. Millions of miles are run every year by gas-lighted trains, and while we are in favour of electricity for other reasons, we do not think that gas is so dangerous that it should be given up. In just the same way it may be argued that the Nottingham points should not have been set to take a train into the branch. But this is to say that all railway officials should be blessed or cursed with a species of second sight, which would prompt them day after day to anticipate the occurrence of what ordinary common sense told them was impossible. No one could imagine that two sane men would drive a train at full speed through a junction where they were in the habit of stopping, with all the signals against them; or that, having done so, a tender could run off the rails, while the locomotive kept on them. So great are the precautions taken in working the railways of Great Britain and Ireland, that no simple accident ever occurs now of a serious nature. Even when a signalman makes a mistake, much time and carefully conducted inquiry are necessary to ascertain, not why he made it, but how it was possible for him to make it. It is because all contingencies seem to be so fully provided for that some catastrophes are never explained. They simply defy the theorists.

The Steam Omnibus.

THE final discussion on Mr. Clarkson's paper, "Steam as a Motive Power for Public Service Vehicles," which took place on Friday night at the Institution of Mechanical Engineers, was on altogether a higher level than those which preceded it. It was especially interesting because Scotland-yard was represented by Inspector Bassom, and something like a practical criticism of Mr. Clarkson's omnibus was heard at last. Furthermore, Mr.

Clarkson's clever reply was full of information. For the first time a definite statement of a principle was carefully laid before engineers, and it has become possible to see the reason for many things mechanical which have till now been obscured.

Those who have read Mr. Clarkson's paper with attention, and examined the drawings of his omnibuses with the care demanded by their minute size, cannot have failed to see that it is one of the most complex pieces of mechanism ever evolved by the brain of man. It is no matter of wonder that Dr. Hele Shaw, while speaking in high terms of the omnibus, should add that, notwithstanding his experience with it, he would be unable to pass an examination about it. The reason why it is complicated was very plainly stated by Mr. Clarkson. After twelve years' incessant labour he has arrived at the conclusion that a steam-propelled vehicle for use in the streets of London, or any other place of much traffic, must be automatic. There are two methods of working. According to one, the driver must be the brain of the machine; according to the other, it must find its own brains. The disheartening fact is that, after all, the automatic mechanism is so far from being competent to take care of itself, that Mr. Clarkson admitted that carefully trained competent men are essential to secure the satisfactory working of his omnibus.

The entire subject is beset with difficulties—difficulties so great that we ask ourselves whether the whole scheme is not radically wrong in some way from beginning to end. We know that steam can be used with good results on common roads for propulsion at almost any speed that the road wheels will stand, so long as we do not attempt too much in the available space. The steam omnibus is handicapped by the use of petroleum as fuel, the "flash" boiler, and superheated steam. Any one of these things by itself represents difficulties; the combination of all three in a vehicle intended to work in crowded thoroughfares piles Pelion on Ossa. We may say at once that Mr. Clarkson has designed and made a beautiful engine, an engine which we fancy will never give any trouble. But the engine must be supplied with steam, and it was not until Mr. Clarkson replied to Scotland-yard that we fully understood how difficult was the problem which he had undertaken. Mr. Bassom said that two things were liable to happen with the Clarkson burner. It would smoke, or it might overflow and cause a serious conflagration under the vehicle. Dr. Hele-Shaw had already admitted that the difficulty of securing complete combustion was tremendous. If the temperature was too high, dissociation took place; there was a waste of heat and imperfect combustion. If the temperature was too low, smoke was given off, and all the passages were choked with soot. This has been known before; but Dr. Hele-Shaw for the first time emphasised the fact that the margin between smoke and dissociation was, with petroleum, very small. Consequently everything turns on the efficiency of an exceedingly ingenious thermal governor. "This," says Mr. Clarkson, "is a most vital part of the generator combination, since upon it depends, not only the regular and efficient working, but the very existence of the boiler itself." A little further on in his paper we learn that the governor depends, in its turn, for its action on the temperature of the steam, and that again, in its turn, depends on the governor, or, in other words, the supply of oil to the fire. But while this is supposed to suffice while the engine is running, it will not suffice when the engine is standing, for reasons set forth in the paper, and therefore a loaded piston supplements the thermostat, so that both pressure and temperature are used for control. Now we do not hesitate to say that it passes the wit of man to determine rapidly and within narrow limits what the temperature of superheated steam in a flash boiler shall be; and we were in no wise surprised to hear Dr. Hele Shaw say that during a trip from Chelmsford to London he saw the pressure gauge rise to 1000 lb. on the square inch, and wished he was any place else. Regulation had failed over a range of 500 lb. or so on the square inch. In point of fact, regulation only takes place within wide limits; indeed, this seems to be the rule with all automatic gear, at all events when applied to steam vehicles; and the reason is obvious. None of these devices can anticipate. The supply of fuel will not be cut off until it is already too great; it will not be put on again until the pressure is too low. There is in all cases a more or less wide range of action to be allowed for, and this is the great objection to automatism. It can only be secured at all by the aid of complex mechanism, and is of necessity always late in its action. The "personal error" of any automatic device varies. With great care and constant attention, it may be kept quite small; but neglect tells its own story at once; and, under any conceivable circumstances, careful adjustment must originate and be continued with the life of the device, whatever it may be.

Leaving the burner, we turn to the boiler. Coil boilers of the kind used by Mr. Clarkson are very curious in their action; very anomalous things take place inside them. Mr. Clarkson and other speakers referred to the ratchet action—that is to say, water gets into any particular place and cannot return; but it came out on Friday night that even Mr. Clarkson's boiler will send water instead of steam into the engine. In point of fact, what is essential to good working is absolute uniformity of conditions. An even temperature of fire, an even supply of water, an even demand for steam. Unhappily, these are just the conditions that cannot be secured in our streets. In the struggle to overcome the difficulties due to environment, Mr. Clarkson has manifested almost superhuman ingenuity. That he has attained success in Torquay seems to be proved. But we cannot help asking ourselves whether as good, or even better, results could not be had by trusting more to the intelligence of the driver and less to automatism? As it is, the driver has much to attend to. As Mr. Bassom pointed out, he still has five levers to control. If the automatism of the machine was perfect, then anyone who could steer would make an efficient driver; but this is not the case. As we have said, a highly-trained man is essential; and it is on the employment of such men that Mr. Clarkson relies for eliminating the defects which Mr. Bassom has found to attend the working of the steam omnibuses submitted to Scotland-yard.

The questions which present themselves for discussion, and, indeed, dispute, are legion, but concerning one fact there can, we think, be no difference of opinion. Mr. Clarkson has brought not only twelve years' experience, but a quite abnormal amount of ingenuity, to bear in trying to solve the problem of steam propulsion in our streets. If it can be done at all on the lines of automatism, he has done it. He deserves success, if ever inventor did. If he fails, we feel sure it will be because he has acted throughout on the assumption that for a public service steam vehicle it must be automatism or nothing. This is not our view; none the less do we appreciate the result of Mr. Clarkson's labours.

American Warship Design.

It is almost an axiom in this country that in the United States they are not very particular what a warship is so long as she "whips creation" on paper. Those who hold this view will find their faith severely shaken by the singularly able paper read by Naval Constructor Robinson at the last meeting of the Society of Naval Architects and Marine Engineers of America. The opinions expressed are understood to be those of the Bureau of Naval Construction, to which Mr. Robinson belongs, but the paper is of interest outside this, on account of the remarkable clarity of view possessed by the author.

Mr. Robinson begins with the Indiana, and tells us—what few of us have ever realised before—that that ship was designed as a "coast defender" pure and simple. Hence many of her obvious defects when regarded as a battleship of ordinary type. She is, as a matter of fact, merely a monitor of large size and large secondary armament. The Iowa, says Mr. Robinson, was an attempt to turn the Indiana into a sea-going ship. Thence he traces the course of the modern American navy, with many candid admissions as to the difficulties before naval architects. Quite a formidable one, he says with emphasis, is the modern demand for increased comfort on board—bath-rooms, and so forth. Without any beating about the bush, the author describes these as peace-time attributes, and shows that, on a given displacement, every comfort means a corresponding loss of efficiency. These comforts are demanded, and they must be supplied; but they have be paid for somewhere in the total displacement. Of course this is a truism; but Mr. Robinson has been the first to tackle it boldly. In the British Navy we used to tackle it by omitting most of the comfort; but we refrained from explaining why. The American Board of Construction apparently intend to try and follow our example in being adamant in their refusal of the combined hotel and warship ideal, which, in some navies, has made so much headway of late. Mr. Robinson is nothing if not combative. He makes mincemeat also of the idea so much favoured in the mercantile marine that warships are "flimsy" in any way, and will apparently have none of the attempts sometimes made to gauge warships by merchantship practice and merchantship experience. "The conditions differ," he insists. Many other points of a like nature are similarly dealt with. The best axiom of any we may paraphrase as follows: "Stick to the original design. Any 'improvements' will entail a general deterioration and considerable delay in construction." These are words of wisdom from a man who knows.

It is not necessary to follow Mr. Robinson through his review of past American construction, except to note how continually he emphasises the constant call upon naval architects to provide for fresh necessities, such as improved coaling facilities, storage of high explosives, and so on. All these, of course, are matters that force themselves upon the average naval architect without any need of reminders. But, as we have already mentioned, the popular idea is that in America they do not bother over much about these things. After reading Mr. Robinson's paper, we are driven to suspect that no nation bothers so much. We turn, naturally, to see what he has to say about new construction. In this, as in all other matters, he is explicit. He is slightly vague on the speed problem, but slightly only. He asks: Would two knots extra speed, purchased at the cost of fewer ships, enable an admiral to force action? Would it enable him, other things, ship for ship, being equal, to win that action against a fleet of the same money value? The reply is fairly obvious. Thence he proceeds to the S. Carolina and Michigan, in which both cost and displacement were fixed before the naval architect commenced his labours. The point is one that all critics of these ships ignore. Without these limitations it is easy to design something better than the Dreadnought; but to design a Dreadnought on two thousand tons less displacement is quite another matter. As a result the Construction Bureau had to eliminate superfluous details. Excessive speed was one. Armour against mines and topedoes was another, bulkheads and three skins being substituted. Bow armour has been omitted, and there is merely a courtesy belt at the stern. Power is concentrated amidships. The aim has been to produce a ship suitable for fleet action rather than a vessel for individual combat against something similar to herself. This has led to a strict elimination of features which may be described as "luxuries" rather than "necessaries," and Mr. Robinson emphasised the fact that the peculiar arrangement of guns firing over each other is designed, not for end-on fire, but to secure the maximum broadside in the minimum space.

The discussion that follows papers of this nature is generally as instructive as the paper itself, and it was so in this case, especially when Commander Hovgaard rose. Commander Hovgaard's decided and original views on naval architecture have already been discussed in our columns. He pronounced himself in favour of a mixed armament—the trend of thought now obtaining here—a view subsequently described as "retrograde" by Mr. Reid, a British speaker. The Commander's other remarks appear to have created some misconception and heated argument. As we follow the report, he is not against large dimensions, but against any forcing of the pace in them, on the grounds that though the future may see increases, it may also see decreases, owing to the advent of new conditions. If the speed be kept down, 18,000 tons is ample for any battleship to-day. "Let increases be conservative," he argued, "and only after all other and technical means of improvement have been exhausted." Thence he proceeded to his well-known crusade on the subject of the metacentric height. In his view, all existing ships are unsafe in battle conditions, and the average metacentric height of 3½ft. to 4½ft. ought to be at least 6ft., and would be better at about 8ft., for an 18,000-ton ship.

On matters engineering Commander Hovgaard had a good deal to say. He advocated oil fuel, of which the United States navy will have none. He also made an appeal for a different type of boiler, advocating the adoption of the small tube type on the grounds of quicker steam raising. The battle of the tubes is not a new one, and it went no further in this discussion than elsewhere, except that the fact that every water-tube boiler is a compromise was very fully brought out. The whole boiler question depends much upon other matters than the efficiency of the boiler as a boiler. Hence the continual changes and shifting from type to type in search of the ideal mean. Added to this are the purely military questions of quick steam raising and coal economy—both antagonistic to many other qualities of convenience. Commander Hovgaard expressed the military view pure and simple. That was the general view of ten years ago. To-day general utility is the favourite criterion. None can say what it will be to-morrow, save that opinion will never be unanimous as to what sacrifices should be made, or what extra labour imposed upon the engineering staff for the sake of certain military advantages. Every water-tube boiler claims to concentrate in itself the ideal mean;

but the real question is which is the best compromise. The battle of the boilers must be an eternal battle so long as steam endures, and the irresistible conclusion is that all types are nearly on a par, and for every excellence have some corresponding defect.

Coal Consumption by Locomotives.

CRITICISING last week Mr. Bell's statements concerning the work done by locomotive firemen, we assumed that big "Atlantic" type locomotives might burn 60 lb. a mile. The context showed, as we thought, that this was intended to make the case for Mr. Bell as good as possible, and was in no sense official. We have received a very interesting letter from Mr. Churchward, chief mechanical engineer of the Great Western Railway. He thinks that our assumption may be misleading. He has just had the coal consumption for all the Great Western "Atlantic" and six-coupled express engines during the last five months worked out, and finds that it averages only 38 lb. per mile for the "Atlantics" and 37·3 lb. for the six-coupled engines. "The compounds even only come out at 40·4 lb." This is, no doubt, exceptionally good work, and supports the opinion which we have so often expressed, namely, that for high speeds there is nothing to be gained by compounding. There can be no doubt about the accuracy of the figures, as they cover the very large mileage of all the fastest and heaviest Great Western trains. May we venture to hope that other engineers will follow Mr. Churchward's excellent example, and let us know what their big engines are burning?

THE NEW INCANDESCENT ELECTRIC LAMPS.

No. III.*—COMPARATIVE EFFICIENCY OF THE DIFFERENT SYSTEMS OF ILLUMINATION.

THE great improvements in the technics of illumination which have been brought about during the last thirty years comprise not only an increase in power of light, but also a cheapening of the illuminant and decreased consumption of energy. In deducing the value of a system of lighting from the cheapness of the unit of illumination produced, the public are often led quite astray. In the competition between the various systems of lighting, tables are often drawn up by the manufacturers compiled from the scientific results of well-known men. These tables purport to show the value of some particular form of lamp, but they fail to indicate the conditions under which the results were obtained, whether the reflectors were used or not, or whether the results are calculated for the whole sphere or only the hemisphere of illumination. A true comparison is only possible when all the conditions and requirements are taken into account. For instance, it is not possible simply to compare a certain source of light in regard to the illumination of a single place in a closed room with a second which serves to illuminate a large room or a hall; in many cases also in the application of a source of light the colour of the light must also be taken into account. It must also be noted that the technical efficiency of a single source of light does not give us at the same time information about the price or the cost of working. Electricity, for instance, is a form of energy which, in the present state of industry, costs much more than the equivalent amount of energy would cost in the form of paraffin or illuminating gas; it is, without doubt, a luxurious form of energy. This, however, is a purely external consideration, which may and does alter from day to day.

After the incandescent petroleum light, the incandescent gas light is the cheapest light, and, in the struggle between gas and electricity, it has succeeded, in spite of the most difficult circumstances imaginable. To the prophecies which have not been fulfilled belongs that which stated that gas light would soon be pushed into the background by the electric light. The two competitors still compete courageously with one another, and to this struggle we are indebted for the incentive to progress. The gas consumption in the last decade shows that the gas engineer need not despair. In the year 1859, 1400 million cubic feet of gas were burnt, whilst to-day the consumption amounts to more than 28,250 million cubic feet.

In spite of its expensive working, the incandescent electric light has found an extraordinary dissemination, a sign that a great demand exists for a small electric lamps suitable for the illumination of interiors. As the gas lighting technicians, on the one hand, have attempted to replace the large electric lights by intensified gas lamps and the like, to which the electro-technicians have replied by the creation of the flame arc lamp, so, on the other hand, electro-technicians and chemists, even the discoverer of the incandescent gas light himself, as we have already related, have endeavoured for years to produce an economical incandescent electric lamp.

Of all the new incandescent electric lamps brought on to the market up to the present, none have been able to supplant the carbon filament lamp, in spite of its high consumption of current. The Nernst lamp, on which the greatest hopes have been placed, because it only required about half as much current, tolerated high voltages, and could be easily connected up, is handicapped on account of the necessary preliminary heating and resistance coil for the glow rod, which makes it dear to manufacture.

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The osmium lamp, the improvement of which is still being pushed forward zealously, as is the case with the Nernst lamp, has also the disadvantage of a high cost of production, and, moreover, will only work with low voltages. The highest so far used is only 47 volts. The lamps must, therefore, be arranged in series for the ordinary voltage supplied. This means always burning several at a time, or else special devices must be used to divide the voltage. It is possible that the voltage may now be raised so that two lamps can be burnt in series, but this advantage can only be attained by an increased cost of production. The consumption of current amounts to 1·5 watts per candle, which is, therefore, about half that of an incandescent carbon lamp; the life is about the same as that of a carbon lamp, perhaps a little less. Compared with the Nernst lamp, however, it has the disadvantage that it can only be used suspended, since the curls of the osmium filament tend to bend on account of it becoming soft when incandescent.

The current consumption of the tantalum lamp is about equal to that of the osmium lamp; it has, however, the advantage over the latter that, on account of its long filament, it can be used with 110 volts; it possesses the further advantage that it can be fixed in all positions. It may be taken, too, that the tantalum lamp will also be manufactured for higher voltages. The profitable existence amounts to 400-600 hours of illumination, with a total life of over 1000 hours. Careful protection against vibration is at first not very necessary, but later on it is essential. The filament easily breaks, and even if the single ends on contact fuse together again and the lamp goes on burning, yet such a shortening of the filament takes place that it is soon destroyed on account of the increased current. On the other hand, because the specific resistance of tantalum increases with the rise in temperature, the lamp is not so sensitive to changes in voltage as is the carbon lamp. It gives, like the osmium lamp, a continuously steady white light. A further, if only a small, advantage is that the illuminating surface is larger, and distributed more uniformly over the circumference of the lamp than is the case in a lamp with one or two curves. The tantalum lamp proves to be very regular, and different lamps tested have shown only very little difference from one another. The illuminating power of the tantalum lamp, according to the researches of Ambler, varies with the voltage to a much smaller degree than is the case with the carbon filament lamp. In this respect, the curves of Kenelly and Whiting are considerably different from those of Ambler, in so far as the difference between the tantalum and the carbon lamp is nothing like so large as Ambler makes it. According to Ambler, an increase in voltage of 4 per cent. causes an increase in light of about 24 per cent. in the case of the carbon lamp, but of only 9 per cent. in the tantalum lamp; and in order to produce the same change in the light power in both lamps, the tantalum lamp requires twice as great a change in voltage as the carbon lamp. This small variation in the illuminating power of the tantalum lamp with the voltage can be partly explained by the fact that the tantalum filament, with higher temperature, illuminates as the carbon filament, since with higher temperature the exponent of the absolute temperature, with which the illuminating power varies, decreases. The higher voltage undoubtedly corresponds, however, to higher temperature, and we are therefore obliged to accept that equal changes per cent. in voltage in both lamps are followed by equal changes in illuminating power. This observation is only true if the resistance of the incandescent filament in both kinds of lamp changes in the same degree as the voltage. As we have seen above, however, this is not true in this case. This difference need not surprise us, since the tantalum filament possesses the positive temperature coefficient of a metal; the carbon filament, on the other hand, the negative coefficient of carbon. Carbon gradually loses this negative character at first; at a voltage slightly under the normal the temperature coefficient becomes zero, and then gradually becomes positive. This explains the difference in the lamps in respect to light variations; equal increase in voltage results in a smaller rise in temperature, on account of the increase in resistance, than in the case of the carbon filament lamp.

This fact also explains why the specific consumption decreases with the rise of voltage in the case of the tantalum lamp to a less extent than in the case of the carbon lamp. According to Ambler, a 5 per cent. increase in voltage made a decrease of the specific consumption of only 12 per cent. in the former lamp, but with the latter 30 per cent.

The present considerably reduced price (2s. 6d.), and the higher voltage of the tantalum lamp give it an advantage over the osmium lamp. Unfortunately, the tantalum lamp is not suitable for alternating current, and it is extraordinary that with it the recently manufactured lamps seem to last much less time than when they first appeared. The cause of this most unusual occurrence has not yet been made known.*

The newer zirconium lamps are said to burn, according to the data of their manufacturer and Boje, with 1 watt per candle, the average existence being at least 500 hours. Zirconium lamps are to be brought on to the market adapted for voltages up to 110. The price of a 40-volt lamp amounts to 3s., a 75-volt 3s. 6d., and 120-volt 4s. Provisionally, however, low voltage lamps are chiefly manufactured, and the results, communicated by Boje in a lecture, only refer to lamps of low voltage.

The iridium lamp of Gülcher is only manufactured for low voltages up to 24 volts. The price of a 12 or 24 voltage lamp amounts to 3s. 6d. The lamps are said to burn with 1 to 1·5 watt per candle, but reports of comparative results and trials on the duration of burning are not available.

* According to the latest reports of the manufacturers—Siemens and Halske—the tantalum lamps have recently been much improved, and are now also adapted for use with the alternating current. The average life of the 25 candle-power lamp amounts to 300 to 400 hours, and the 50 candle-power lamp 500 to 600 hours. The lamps are already being used with alternating current. See the "Technische Rundschau" of the *Berliner Tageblatt*, No. 46, of November 14th, 1906, page 629.

The latest arrival in the field of metallic filament lamps is, as we have previously said, the tungsten lamp We have to distinguish between tungsten lamps, which are manufactured by four processes. The first process is that of Just and Hanaman. The manufacturers concerned have the intention of producing a normal type of 30-40 candle-power for 110 volts, and with about 1 watt per candle. Researches have been undertaken with these lamps in the laboratory of the municipal electricity works of Munich; the illuminating power is given as 38·9 to 45·7 candles, with a specific consumption of about 1·1 watt per candle.

The second process is that of Kuzel. The Kuzel tungsten lamps were tested in the Sirius works of Kremenecky, in Vienna, and gave for lamps of about 19-32 volts an economy of about 1 to 1·25 watt, with a useful existence of 1000 hours, in which the average decrease in illuminating power did not amount to more than 10-15 per cent. of the original. Several Kuzel lamps were examined at the testing house of the Austrian Purchase Board. A 55-volt lamp showed, at 1·1 watt for one candle, 35 candles; and after 917 hours, 28·6 candles at 1·18 watt for one candle; the decrease in illuminating power amounted to only 7·6 per cent. in the 917 hours. According to the assertions of the manufacturers, one curve of the filament will sustain about 30 volts, so that lamps with three filament curves can be manufactured for altogether 110 volts. Burning through is said, as with the tantalum lamp, only seldom to render the lamp useless, and also seldom to have any real effect upon the life of the lamp, since in almost all cases in which the filament parts a fusing together again takes place, so that the lamp burns on again of its own accord. The cost of production is comparatively low, and the greatest efforts are being made to bring the lamp on to the market for the next season.

The tungsten lamps, manufactured according to the third process by the Osmiumlicht-Unternehmung in Vienna the so-called Osmin lamps, were tested in the laboratory of the municipal electricity works of Munich, and gave at 110 volts, and 1·05 watt for 1 candle, 57·23 candles. The same lamps were further tested in the museum for arts and crafts in Vienna; they burned with 1·03 watt per candle, and after 1776 hours burning still showed 1·09 watt for one candle. The Osmiumlicht-Unternehmung of Vienna intend to produce lamps of 40, 50, and 60 candle-power for 105 and 110 volts; at 200 volts the lamps will have 80 candle-power. For these types of lamps filaments are required having a diameter of 0·03 mm. A fine human hair has a diameter of about 0·06 mm. One can therefore take it for granted that it will not be possible to manufacture lamps of less than 36 to 40 candle-power for the usual voltage of about 110 volts. This, however, is not such a great disadvantage from one point of view, since this 40-candle lamp, on account of its economy of 1 watt for 1 candle, is equivalent in consumption of energy to a 10-candle carbon filament lamp.

Concerning the fourth tungsten lamp, which is to be brought out by the Deutsche Gasglühlicht Gesellschaft as the Osram lamp, the company itself gives the life, on the average, as over 1000 hours, during which time no diminution in illuminating power is said to take place. According to a test record of the technical-physical Reichsanstalt, sixteen Osram lamps, of 25 to 32 candle-power, were tested for life and constancy of light by means of alternating current, and the results, on the 21st of May in the current year, at which time the sixteen lamps had been burning 500 hours, showed that, in the case of the 32 candle-power lamps, there was an increase in illumination of about 2 per cent., whilst the 25 candle-power lamps, compared with their original brightness, had not quite lost 1 per cent. The sixteen lamps burnt out as follows:—One each after 156, 512, and 872 hours, two after 700 hours; and it is to be noted that the burnt-through filaments fused together again. After 958 hours' burning, the filament of a lamp burned through and welded together again, so that this lamp, at the close of the experiment on June 28th of this year, was still burning, and therefore reached 1000 hours. The Osram lamps can be burnt with alternating and direct current, which is important, as it had been shown that the tantalum lamp and Nernst lamp were soon destroyed by the alternating current. The specific consumption of energy amounted, after 500 hours in the case of the 25 candle-power lamps, to 1·12 watt for one candle, and for the 32 candle-power lamp to 1·08 watt for one candle. After 1000 hours these relations had only changed quite insignificantly. The Auer Gesellschaft intends also to manufacture Osram lamps for 220 volts at 40 and 50 candle-power, with a specific consumption of 1·2 watt for one candle, and from 50 to 200 candles with one watt per candle. According to the assertions of this firm, the life, with full constancy of illumination, amounts generally to over 1000 hours.

The current consumption of the three ampère Hewitt lamp amounts to 0·33 to 0·15 watt for one candle, which about corresponds to the best results yet attained with the flame arc lamps. With reference to the permanence of the lighting power, and the steadiness of the burning, the mercury vapour lamp has not yet been beaten, particularly as somewhat considerable changes in voltage are without influence. The chief merit of the mercury lamp, however, consists in the fact that no attention and no regulating is necessary, and that the illuminating power, as far as the experiments have yet reached, remains unaltered. The life of the Hewitt lamp, when carefully handled, leaves little to be desired. Lamps which were still in good condition had attained a life of 7000 hours and more. The price of a mercury vapour lamp of 75 cm. length, with 500 to 600 normal candle-power, amounts in America, with the inclusion of all accessories, to 30 dols. (£6). The quartz lamp of Heræus, which consists of very expensive quartz glass, transparent for ultra-violet light, costs £15, including the connections. The

U vial lamp of Schott, about 25 cm. long, with holder, is quoted at £6 5s. We have already stated that the bluish-green colour of the mercury vapour lamp, which is very unpleasant, is the chief obstacle in the way of its general introduction.

After these considerations, the question is forced upon us: Which light will finally remain victor, and supplant the usual systems of illumination? Electricity, illuminating gas, petroleum, alcohol, and acetylene have entered into keen competition. Even if enormous strides have been made with the new metallic filament lamps, the efficient results of which, for the development of electro-technics as a whole, gives rise to great hopes, nevertheless it is probable that none of the existing systems of illumination will soon entirely supplant the others. The field is too large, and even if still more new sources of light should be discovered, there is room for all to exist side by side. The light of the old carbon filament lamp is certainly dearer than in all other lamps. Hence it is possible that in future consumers will not employ the carbon filament lamp with its cheap cost of production so widely, on account of its high working expenses.

There is talk of a tungsten lamp having four times the illuminating power of the carbon filament lamp, namely, a specific consumption of energy of about 0·8 watt per candle; some even anticipate 0·5 watt per candle, and the end of the incandescent gas light. It is still, however, a question whether we shall soon really possess an electric lamp so economical as only to need 0·5 watt per candle. At present it is only the optimists who think so, since the new tungsten lamps are not yet out of the laboratory stage of manufacture. The makers are not particularly willing to publish important results prematurely. We have already seen that a large number of inventors are working on the production of the tungsten lamp; it must, however, be noted that in all countries where an examination of patents in respect to novelty takes place, particularly in Germany and Austria, none of the above-mentioned patent applications except the first one by Just have up to the present been accepted. It is yet to be seen which of the various processes can secure effective protection by patent, and it is not yet known which of them in practice will produce efficient lamps.

Whether the new tungsten lamps will fulfil the far-reaching expectations placed in them cannot, of course, be proved until they have received a thorough trial under practical conditions. Electric lighting with glow lamps has always been a luxury. With a consumption of 0·5 watt per candle, electric light will be just about as cheap as the incandescent gas light, provided the price of electric energy remains what it is at present, namely, 5 to 6 pence per kilowatt-hour.

The difficulty of producing high-voltage filaments from metals with high fusing points, the necessity of using the lamps in prescribed positions, the delicacy of the filament substance, &c.—all these have almost completely been overcome, or, at least, set aside.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE discussion on Mr. Clarkson's paper on "Steam as a Motive Power for Public Service Vehicles" was continued and concluded at the Institution of Mechanical Engineers last Friday evening. Judging from the attendance, which was again large, the interest which this subject aroused among the members did not appear to have abated, and the short discussion which took place was of much more interest and much more to the point than that of the two previous meetings. In the absence of the President—Mr. E. P. Martin—the chair was taken by Mr. T. Hurry Riches.

After the preliminary proceedings, the Chairman called upon Dr. Hele Shaw to open the discussion. In response, Dr. Hele Shaw remarked that he would be sorry if the discussion closed without any reference to the difficulties that Mr. Clarkson had had to overcome, and to the manner in which he had mastered them. These difficulties had baffled scores — indeed, hundreds — of inventors, and probably the detail which had caused the most experimental work, and yielded the least amount of success, was the burner. The difficulties in designing a burner to work on heavy oil were enormous. He only mentioned two, which he considered to be the greatest. The first was, that if the vaporiser heated the paraffin too much, the hydro-carbons were dissociated. And secondly, if the vaporiser was not sufficiently hot the paraffin was too cool and condensed. Between these two conditions there was an extremely small margin. With generators there was usually a difficulty which Mr. Clarkson had ingeniously overcome by introducing what he termed a steam ratchet. There was always water at the top of the boiler and steam at the bottom. When the boiler was stopped the steam rose and allowed the water to descend and come into contact with the hotter tubes at the bottom. This action was prevented by providing the "steam ratchet." Some such device was a necessity in motor omnibuses, owing to the large number of stops they were required to make in the course of a day's run. In the old steam-driven vehicles the mechanism was simple, and there were really few parts. On examining the general arrangements of the Clarkson system, given in Fig. 1—which was reproduced in our issue of November 23rd—one could not help but be struck with the complexity of the pipe lines, and yet he believed there was not a single redundant part in the whole system. Mr. Clarkson had adopted this complex arrangement because it was absolutely necessary. The speaker's opinion was that the system was ideal. A man was able with it simply to sit and steer the car. He had recently been to Paris, and seen what they were doing there, and he was of opinion that we in this country had nothing to fear in the way of rivals from anything that could come from across the Channel.

The Chairman then called upon Superintendent Bassom, of Scotland Yard, who, in response, criticised steam omnibuses rather severely. He did not deal with their good points, but emphasised the defects which the authorities at Scotland Yard wished to see remedied. He stated that they wanted, in the interests of the public, to see the best vehicles in use, irrespective of the propelling power or type. He dealt briefly with the history of the steam vehicle from Hancock's time to the present, and asked why they had not been more generally adopted. He stated that out of 800 motor omnibuses in London, only 40 were steam driven. He drew attention to the fact that the steam trams which ran in the north of London years ago — at Hounslow — were a failure, as were also some steam omnibuses which were in operation in another part of London some time ago. He had much to say regarding the advantages claimed by the author for steam vehicles. Dealing with the first—"the employment of a safe and cheap fuel"—he suggested that paraffin, although safe at ordinary temperatures, when heated by hot tubes was not at all a safe fuel; and to substantiate this statement he referred to the large number of fires that had occurred, which he attributed to the burner. In fact, he did not think that it was so safe as petrol if the latter was under equally good condition of storage. With regard to cost, here again he could not agree with the author. Taking the price of paraffin at 5d. per gallon, and that of petrol at 10d., he estimated the distance that a steam omnibus could run on a gallon of fuel at two miles, expressing the opinion that the author had slightly under-estimated the fuel consumption. For in the paper the consumption was given as 2½ miles per gallon. For a petrol car, he thought seven miles was about correct. It would therefore be seen that the latter had a very great advantage in this respect. He observed that the smell was worse in a steam omnibus than in other types; in fact, it was an extremely smelly vehicle. Flexibility of the engine he admitted, but could not endorse the author's statement as to the simple control. The driver had to look after so many parts that in the end the steam omnibus was not so simple as a petrol vehicle. The burner was then severely criticised. Superintendent Bassom said that it was not altogether such a simple piece of mechanism as it looked. Three weeks ago he tried to take a brake test, and they had difficulty in getting the vehicle to start. Mr. Clarkson had stated in the paper that it only took 50 seconds to start. On this occasion, after he had ground away for ten minutes, there was no result at all, and as soon as the burner did light they nearly burnt the shed down, due to the liquid paraffin in the burner escaping, but fortunately they had plenty of sand at hand. Those who had seen the omnibuses running at night time must have noticed the glare of the burners on the road. And at times a flame about 2ft. long shot towards the ground in the form of a cascade. The amount of smoke emitted at the present time was alarming. One or two causes for this suggested themselves to him, the cooling of the vaporiser or too little air for the burners. The author had suggested the employment of a canopy to enable the products of combustion to be discharged upwards, but they at Scotland Yard strongly objected to this construction for reasons which Mr. Clarkson was well acquainted with. On being asked by Mr. Clarkson publicly to state the reasons, Superintendent Bassom remarked that the wind pressure would be enormous when a canopy was fitted, and the engines, in consequence, would have to be made more powerful. Then there was also the wind pressure on the sides of the vehicle to be considered. At present the omnibuses were quite safe, and there was little chance of their overturning, but if a canopy was introduced the factor of safety would be considerably reduced. He admitted that several of the roads had too much camber, and in these cases the danger would be further enhanced. Collapsible canopies were quite out of the question. He considered that skidding was one of the most serious and difficult problems that the authorities had before them. One speaker had remarked that the difficulty had been overcome at Torquay. If this really was so, he would like to know the secret. He thought that the steam omnibus showed more tendency to skid than the petrol type. He offered the explanation that it was due to the two tanks carried behind the back axle containing the paraffin and water. When the motor omnibuses got on a steep camber, all the liquid got down to the end of the tank, and the surging motion helped the vehicle to continue to skid after it had once commenced doing so. He suggested that the difficulty should be overcome by putting baffles in the tanks to prevent the surging action of the liquid. With regard to steering, the Clarkson omnibus had, in practice, been found to be rather slow. In his opinion, the best system had been adopted, and probably its slow action was due to using a worm with a fine thread, or to the large weight at both ends of the car. Whatever the reason, the fact remained that it was slow. Dealing with brakes, Superintendent Bassom said that, notwithstanding the use of the throttle for pulling up or slowing, the brakes were used very much. He did not like the internal expanding brakes used by Mr. Clarkson, because they were so difficult to adjust, and when this was the case it generally meant that they were left alone when the car was being examined in the garage. The hand brake was also difficult to adjust, and he agreed with a previous speaker that the adjusting screw was in the wrong position, and if altered as suggested, the adjustment would be much simplified. In conclusion, the speaker thanked the Institution on behalf of the Scotland Yard authorities for the opportunity afforded them of placing their views before the members.

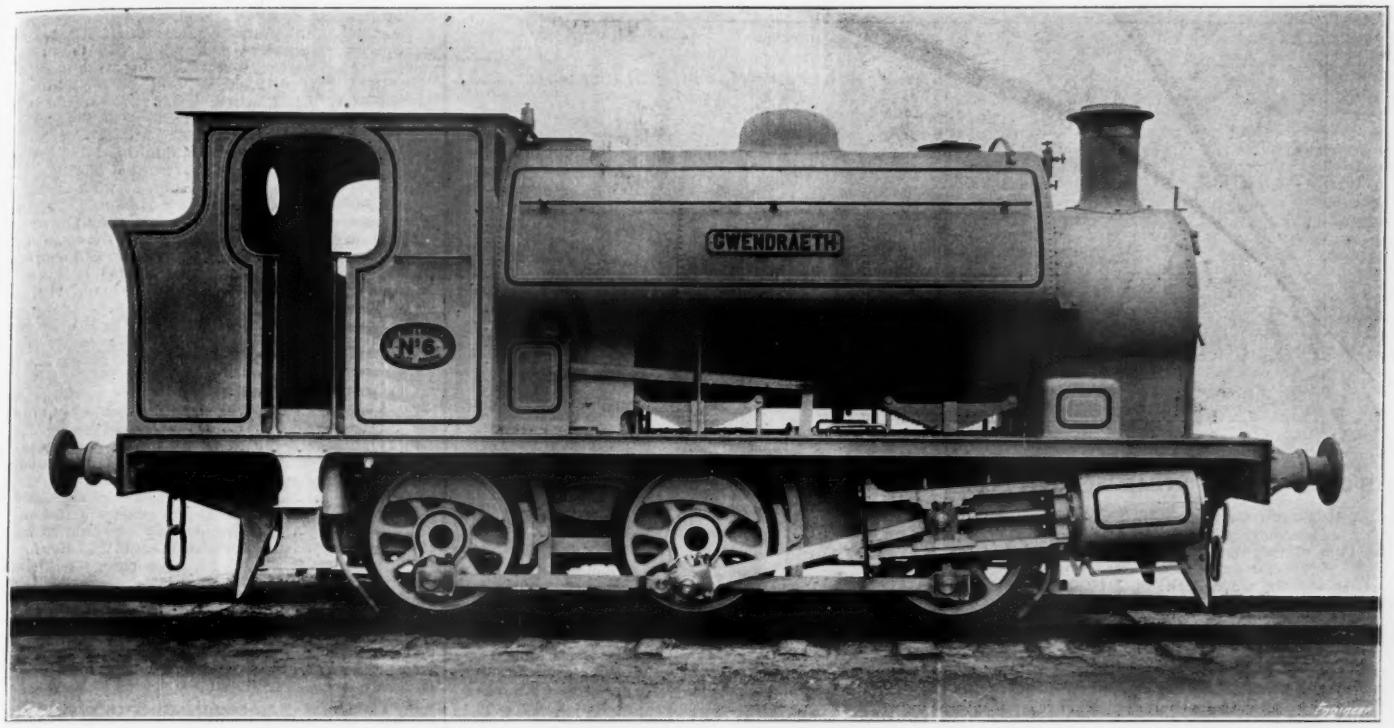
Mr. Johnston regretted the lack of data regarding the working of Mr. Clarkson's omnibuses in London. He could not endorse all the advantages claimed by the author for steam-propelled vehicles. For instance, it certainly was not the case that there was an absence of smell. And as to the safety of this system, he had seen two fires, both of which he ascribed to the flooding of the burner. He was doubtful about the reserve power for climbing hills. He had several times seen petrol omnibuses overtake the steam type on gradients situated between Notting Hill and Shepherd's Bush. He was of opinion that towards the top of a hill the boiler began to prime, and the engines then became hot-water engines. So far as he could see, there was no remedy for this on the Clarkson omnibus because the regulation of the fuel and water could not be controlled separately. All that could be done was to cut off the supply of steam by hand, and this was impossible with the automatic control adopted.

The Chairman then called upon Mr. Guy Beaumont. He referred to what he thought still surprised engineers, who had not only to be accustomed to what was known in common steam engine practice but what was customary with steam vehicles. It still seemed surprising that engines working at a pressure of more than 1000 lb., and with steam at over 1200 deg., could be run so economically as they can in such small engines as 20 horse-power. He divided the control of steam omnibuses into two systems, that in which the fuel and the water were regulated automatically, and that in which the supply of fuel and water were under the control of the driver. From the economical point of view there was little to choose between the two systems. But from the driver's point of view, especially in heavy traffic, the automatic system ought to be advocated, because it allowed the driver to pay more attention to the road.

Mr. Clarkson, on rising to reply, thanked the members for their most cordial reception of his paper. It was written, he said, with the intention of bringing before them a history of twelve years' work with steam vehicles, and also to call forth a discussion. He thought that the most striking part of the paper was that dealing with the results obtained at Torquay; and these had been specifically mentioned because this system had been the longest in use, and also because the figures had been most carefully recorded. With regard to the time lost in the services due to temporary stoppages, he had asked the Torquay engineer how many cars he kept in reserve to maintain the good figures given, and had been informed that there were in all eight cars, and during the summer months one car was always kept in reserve and seven ran. In winter one car was in reserve, one in the paint shop, and six in use to maintain the service. The company which ran the omnibuses had only a capital of £5000, and it paid a dividend of 3½ per cent. It also had £2300 in the bank. The number of passengers carried amounted to one and a-half millions. Dealing with the criticisms regarding the low degree of superheat he used, namely, 800 deg. instead 1200 deg., he stated that at present he was prevented from using high superheat economically because he could only obtain steel which oxidised at high temperatures. It had been stated—by Mr. Smith—that Serpollet used live steam at 1200 deg., and exhausted at 800 deg. He used live steam at 800 deg. and exhausted at 300 deg., and he could not, on the face of these figures, see any economy in adopting the higher superheat. With regard to the employment of automatics, he believed that they should be used, and he was of opinion that the perfection of a public service vehicle depended upon the perfection of the automatics. In answer to several of the speakers, Mr. Clarkson said that the coils of the generator were welded together, and some were joined by the Perkins union. The use of radial spacing bars had been found to be necessary in order to retain the shape of the coils, and also to act as a support. Mr. Fraser had stated that the side skidding question had been almost overcome in Torquay, and Superintendent Bassom had asked how this had been accomplished. When the omnibuses first ran at Torquay they were fitted with good soft rubber tires, which lasted for 25,000 miles. However, the cars skidded, and it was necessary to use Parsons chain to prevent this. In time the firm which supplied the tires used inferior rubber, and although the tires did not last so long, they eliminated the tendency to skid. This was the more remarkable because the roads consisted mainly of oolitic limestone, which, when wet, rendered the surface very slippery. He thought that the explanation was that soft rubber adapted itself readily to the form of the road, instead of forcing its way through the grease, and getting a better grip, as was the case when the poor, hard material was used. Another point which had been raised was the employment of a chain drive. He used this system because it permitted a lighter back axle to be fitted, and, at the same time, it was very efficient. Professor Spooner had referred at some length to the Perkins boiler; he—Mr. Clarkson—thought that Perkins would have got better results had he used a thermal control. He was aware of and had used the anti-friction metal referred to by Professor Spooner, but had found it far too brittle for his purpose. He was interested in Mr. Pendred's remarks, and agreed with them. Scale was carried through the engine with the steam; this was proved by the fact that any pockets in the steam pipes became filled with boiler scale. With regard to the fuel question, he did not think that petrol would always be obtainable at the present figure. The Committee which had been appointed by the Motor Union to inquire into the question of obtaining a substitute had just issued its report. From this it would appear that the only available substitute was alcohol at 2s. a gallon, obtained from potatoes at £2 a ton. He then read a short abstract from Dr. Ormesby's report. In reply to Mr. Stephen Terry, it was stated that hunting cogs were unnecessary now, owing to the better machinery employed in making the teeth of wheels. He did not use a hunting cog on his vehicles. One speaker who had asked if any difficulty was experienced from air locks in the generator, was told that there had been no trouble at all from this source. In reply to Mr. Druit Halpin's statement that the four-bladed propeller condenser fan used by the author was inefficient, Mr. Clarkson stated that numerous experiments had been carried out, and that the four-bladed fan, as used, was

SIX-COUPLED SADDLE-TANK LOCOMOTIVE

THE AVONSIDE ENGINE COMPANY, BRISTOL, ENGINEERS



found to give the best results in practice. Finally, Mr. Clarkson replied to Superintendent Bassom's remarks. He had never had any difficulty with Scotland Yard. It did seem strange that steam had not made more progress than it had. Out of 800 motor omnibuses in London, only forty were propelled by steam; but he thought it was easy to say why. The London omnibus companies some time back were almost forced to put motor vehicles on the road, and consequently had no alternative but to take the omnibuses they could get. The danger of the fuel had been suggested. With ordinary care he thought there was little danger. It was not, however, an easy matter to place a machine like a motor omnibus in the hands of unskilled men, and to get good results from it. He was entirely at a loss to know why canopies should not be allowed on omnibuses as they were on tramcars. Probably it was because the former were controlled by Scotland Yard and the latter by the Board of Trade. The reasons given by Superintendent Bassom were not sufficient. The power of the car had nothing at all to do with Scotland Yard, and if engineers considered that canopies were safe, and did not raise the centre of gravity too much, then he failed to see why they should be prohibited. The wind pressure, he thought, was almost a negligible quantity, and only corresponded to an extra two passengers on the top of the omnibus. He had heard that they were prohibited because it prevented people from seeing advertisements on second floor windows, and probably this was the true reason. With regard to smell, he remarked that it was a most difficult problem to construct a burner that would work well under all conditions. Another point raised by Superintendent Bassom was the slow steering of his omnibus. He considered that it was a good thing to have the steering slow, because omnibuses ought not to be driven round corners quickly, and this they could not do when the steering was slow. Again, it made it easier to steer the car, which was a very important consideration in dense traffic. It also allowed the driver easily to steer with one hand, leaving the other free to manipulate the different control levers.

The discussion then closed, and an abstract of the next paper—"The Lighting of Railway Premises, Indoor and Outdoor"—was read by the author, Mr. Henry Fowler, of Derby. An abstract of this paper will be found in a subsequent issue. The author having been thanked for his paper, the discussion was opened by Mr. A. P. Trotter, of the Board of Trade. He considered that the most interesting part of the paper was the economic. However, data was wanting of comparative costs. The cost per candle-power hour should have been given, as then it would probably have been shown that the most expensive light was that at country-side stations. The question of distribution of light was of the greatest importance, and he was glad to see that the author had dealt with this fully in the paper. The author had stated that, as a general rule, where the horizontal illumination is properly provided for, the vertical illumination will look after itself. With this he agreed; it would, nevertheless, have been more satisfactory had the height of the light from the ground been given. Mr. Trotter drew attention to the illustration of a photometer, the design of which the author had imputed to him, and he disclaimed the invention of the apparatus. He, however, showed and explained a neat photometer which he had brought with him.

Mr. W. Williams, of the Great Western Railway Company, said that the author had made no reference to the difficulty in converting from flat flame to incandescent, which literally meant starting from zero. By adopting incandescent lighting instead of a flat flame, the Great Western Railway Company had saved 30 per cent. This, he thought, was good. The Midland Railway Company was about one year in advance of the Great Western, and had had more modern lamps to commence with. He was of opinion that electric light would always be the correct system, although high-pressure gas was efficient and good.

Mr. Evered regretted that the author had given no figures as to the cost of power per candle-power hour. He had, however, given the figure £1 0s. 6·93d. as the cost per lamp per annum for the Kitson lamp, and this worked out at 0·494d. per candle-power hour. Mr. Evered went on to say that at Sunderland thirty-three such lamps had been installed, and the cost per candle-power, including labour, worked out at ·75d. In the works he was connected with they had now in use a large gib crane, 10ft. long, which was made to swing easily; on this lamps had been suspended. As the crane chain came along it swung the gib away quite easily. By this means the lamps could be brought to within 9ft. to 10ft. of the floor, and thus save the penetration of 20ft. of darkness, which, of course, was important.

The last speaker, Mr. Rodger Smith, referred to electric lighting and to the use of the flame arc. He admitted the difficulty of getting a satisfactory lamp that would burn for more than twelve hours. If a more lasting lamp could be obtained it would be of great value for railway purposes, as with the same amount of energy five times the light would be obtained with the flame arc as with the older types of lamps.

At this point in the proceedings the meeting was adjourned.

SADDLE-TANK LOCOMOTIVE.

A POWERFUL and heavy saddle-tank locomotive—illustrated above—has just been built for the Burry Port and Gwendraeth Valley Railway Company by the Avonside Engine Company, of Fishponds, Bristol. It has cylinders 15in. in diameter, and a stroke of 22in.

The locomotive was specially designed to deal with heavy and continuous traffic, and it is undoubtedly a powerful engine for its size. The boiler is made of best mild Siemens open-hearth acid steel, of a tensile strength of 26 to 30 tons per square inch, with an elongation of not less than 20 per cent. in 8in. The longitudinal joints have butt straps inside and out, and the angle iron ring from barrel to smoke-box is double riveted, as well as the barrel to the fire-box shell. All the holes are drilled in position, and hydraulic riveted. The internal fire-box is made of the best-selected copper, $\frac{1}{2}$in. thick, except where the tubes pass through, where it is $\frac{5}{8}$in. The screwed copper stays are $1\frac{5}{8}$in. diameter, spaced as near 4in. as possible. The tubes are of the best solid-drawn brass, 164 in number, $1\frac{5}{8}$in. diameter, and $\frac{1}{12}$ B.W.G. thick, and the distance between them is in no case less than $\frac{3}{8}$in. The heating surface of the fire-box is 80 square feet, taken above the fire-bars and deducting the area through the tubes and the area of the fire-door ring. The heating surface of the tubes is 774 square feet, and the total is therefore 824 square feet. The grate area is 15·2 square feet. The steam space in the boiler is 38 cubic feet, and the area on the water surface is 49 square feet.

The frames are $1\frac{1}{2}$in. thick, made in one solid plate of the same quality as the boiler plates, stayed together by plate stays, all hydraulic riveted. The wheel base is 11ft. The wheels are 3ft. $6\frac{1}{2}$in. diameter, with tires $2\frac{3}{4}$in. thick and $5\frac{1}{2}$in. wide, the journals being 7in. diameter, and $7\frac{1}{2}$in. wide. The axle-boxes are of cast steel, with phosphor bronze bearings. The cylinders are 15in. diameter, with a stroke of 22in., and are held to the frames by 1in. turned bolts driven into rhymered holes. A double sight-feed lubricator is fitted. The crossheads have two cast iron slides lined with white metal 16in. long and 4in. wide. The crank pins are of crucible cast steel; the big end is $4\frac{1}{2}$in. diameter and 5in. long. A steam brake is fitted and worked in conjunction with the hand brake. Gresham and Craven's patented steam reducing valve is used. The tanks contain 900 gallons of water, and the bunkers 30 cwt. of coal. The weight in working order is about $38\frac{1}{4}$ tons, and when light $29\frac{1}{4}$ tons. This engine, working at 170 lb. boiler pressure, is said to develop a tractive force of 15,840 lb. A somewhat similar locomotive is now being supplied by the Avonside Engine Company to H.M. War-office.

A NEW TIRE MATERIAL.

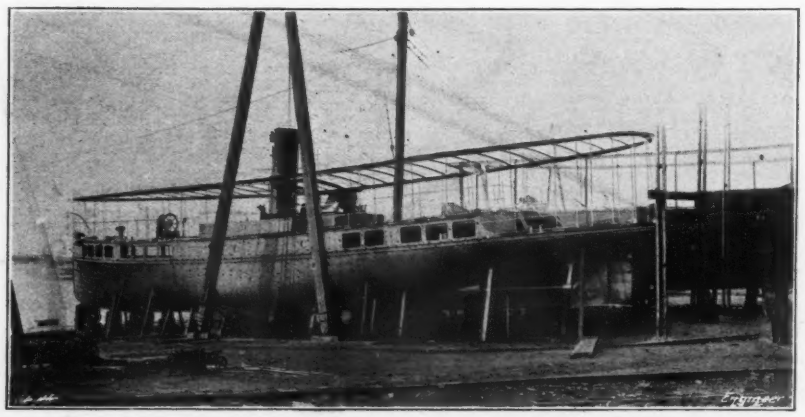
FOR ease of motion over average roads, it is safe to state that the air inflated tire has no immediate rival, and hitherto automobilism—or the pleasure side of the movement—has been absolutely dependent on it. Spring wheels cannot be said to have met with any considerable degree of favour, for the reason that they do not deal with the shocks caused by uneven road surfaces at the correct place, namely, the point of contact. Solid rubber is not sufficiently resilient. A new form of wheel in which there is an inflated rubber tube in the hub has hardly yet come before the public, though a good many claims are made for it. Ordinary pneumatic tires have their disadvantages, the worst of which is the liability to puncture, which the new form of wheel just mentioned is free from. With the object of reproducing as near as possible the resiliency of the pneumatic tire, while obviating its drawbacks, a material called Elastes is now being introduced. It is a mixture in certain predetermined quantities of three ingredients, glue, glycerine, and chromic salts, which are dissolved at a high temperature, and while in a liquid condition are forced into the inner tubes of the tire. The pressure used, and hence the density of the material, is dependent on the weight of the car. After insertion the tube is sealed up.

For the purpose of filling, the inner tube is mounted upon an ordinary tire rim, inside the outer cover, first having an additional valve fitted to it. This second valve is provided to allow the air to escape from the tube while the material is injected through the other valve, and the rim with its filled tube and cover is then stored away for a period of several days to allow the Elastes to set. It is then ready for use. Before mounting the filled inner tube on the wheel a protecting cover of thin canvas is solutioned on to the tread. The wheel is then placed upon a mounting table and the outer cover and tube are stretched over it and secured in the rim in the usual way by the aid of levers. It is claimed that Elastes will retain its consistency under all variations of weight or temperature to which it may be subjected, that long use will not affect it, and that it has no tendency either to become hard or disintegrated; in fact, so long as it is not exposed to actual friction, it may be used over and over again.

The material has the drawback that it adds to the weight of the vehicle rather to the extent of from 20 lb. to 40 lb. per wheel, but it is claimed that from this must be deducted the weight of spare tires, which need no longer be carried. We have had an opportunity of testing the running of a 15 h.p. Siddeley car fitted with Elastes-lined tires, and although the roads were in a semi-frost-bound condition no very perceptible difference of motion could be detected from the riding of pneumatic tires. The makers are the Elastes Company, York-street, Westminster.

TWIN-SCREW FERRY STEAMER

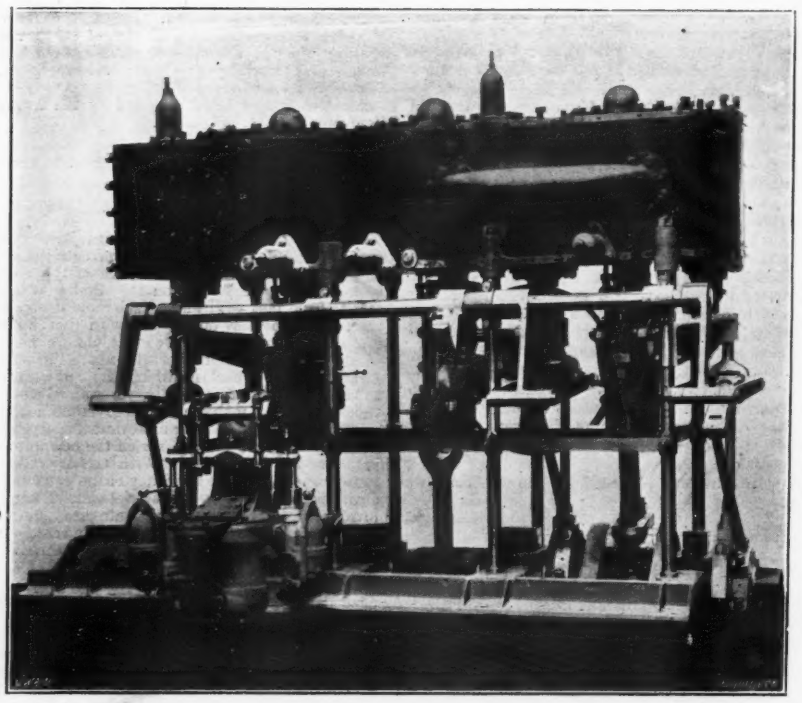
JOHN I. THORNYCROFT AND CO., LTD., SOUTHAMPTON, BUILDERS



TWIN-SCREW FERRY STEAMERS FOR INDIA.

SEVEN twin-screw ferry steamers for service on the river Hooghly have recently been completed for the Commissioners of the Port of Calcutta by John I. Thornycroft and Co., Limited, of Southampton. These vessels were ordered in May, 1906, and the whole of the work has been carried out under the superintendence of Mr. J. H. Apjohn, M. Inst. C.E. Shipment was specified to commence six months after the order, and to be completed in nine months, *i.e.*, by February, 1907. Messrs. Thornycroft have, however, anticipated this, as we understand that shipment of all the boats and machinery was completed by the end of last month, so that the work will have been completely carried out in six months. These vessels, one of which is shown on the stocks and ready for dismantling for shipment above, are 100ft. long between perpendiculars, 20ft. in beam, and 10ft. moulded depth, and have a maximum draught of 5ft. fully loaded, the guaranteed speed being 12 knots. They are arranged to carry, in all, about 200 passengers; seating accommodation has been arranged for 100 of these. The passenger space is divided into two classes, the first-class being situated forward on the upper deck in front of the boiler casing, and separated by portable barriers from the remainder of the space which is set apart for second-class passengers.

On the upper deck there are three wide gangways on either side, giving room for embarking large numbers of passengers quickly. One of these gangways is arranged for first-class passengers and the other two for the second-class. The upper deck has a fine area, and will be capable of accommodating a large number of passengers with comfort. A light wood awning covers this deck. Access to cabins is gained by three open companions. Two are situated forward, one being for access to the first-class lavatory and the other for access to the second-class cabins. Seats are arranged all round the forward and after cabins. Ventilation has been provided for by means of cowl vents through the deck to the cabins, and louvre vents have been fitted around the ship's sides. The machinery consists of two sets of vertical tri-compound condensing engines, supplied with steam from one cylindrical boiler, working under forced draught on the closed stokehold principle. Our engraving shows one of the fourteen engines fitted into these seven vessels.



ENGINES FOR TWIN-SCREW FERRY STEAMER

NOTES FROM SOUTH AFRICA.

(From our own Correspondent.)

JOHANNESBURG, November 12th.

THE trade outlook still remains gloomy. Political rest is denied to the country, and the question of the provision of an adequate labour supply for the mines appears to be the foremost controversial point. There has been talk of attempting to reconcile and combine the views of all parties on this burning subject, but the terms of "give and take" may prove too difficult of adjustment. It is now generally agreed that the prosperity of the country depends, in the first place, on the mines being well supplied with cheap unskilled labour, but regarding the important points—of what colour is it to be, and where and how it is to be obtained—there seems no better chance of agreement now than hitherto.

Meanwhile business is bad locally, and this condition of affairs is reflected all over South Africa. One of the most reliable indicators of prosperity may be consulted by study of the statistics of railway profits. In these the unpalatable facts are revealed that the Central South African Railway is losing revenue, as compared with corresponding periods of last year, at the rate of £776,230 per annum, the Natal Government Railway at the rate of £303,004, and the Cape Government Railway at the rate of £197,829. This latter line is, of course, not so dependent on the Rand trade for its profits, while any decline in oversea imports to the Transvaal is very severely felt by the Natal Government Railway, whose revenue depends so largely on through traffic.

The most important feature connected with the gold mining industry recently has been the decision taken by the various controlling groups with respect to reserve gold. The Eckstein, Barnato, and Neumann groups, together with the Rand mines and the Consolidated Goldfields, have decided to continue the practice of keeping gold reserves in connection with each of the mines under their control, but a declaration of the actual amount in each case is to be made either monthly or quarterly. The Albu and Goerz groups, on the other hand, have decided to abolish gold reserves, and have included the reserve gold in their declarations of the gold outputs for the month of October. The Robinson and Farrar groups have up to the present made no declaration of their future policy in this respect. The object of keeping a certain amount of gold in reserve is to equalise the monthly profits of each mine as much as possible, and so average out the effects of either abnormal expenditure or fluctuations in yield of the ore mined. That there exists no abuse of this useful practice at the present time may be gathered by the fact that the largest statement of gold reserves now made, viz., 13,659 oz. in the case of the Robinson Gold Mining Company only amounts to about 60 per cent. of the monthly output from this mine. The monthly declaration of the gold output for October was, as usual, made by the Chamber of Mines on the 10th inst. It included 14,968 oz. of gold previously held in reserve by the mines of the Goerz and Albu groups. The total output, excluding this amount, was 525,641 oz., of value £2,232,780, which shows an increase over September of 20,530 oz., of value £87,205, which, taking everything into consideration, shows that the rate of gold production has slightly increased. The Simmer and Jack mine was the largest producer, and in this mine 320 stamps crushed 62,010 tons of rock for a return of 23,579 oz. of gold. There was a net increase of 55 stamps at work on all mines during the month.

Regarding native labour, the September improvement was maintained. At the time of writing only the statistics of the working of the Witwatersrand Native Labour Association are available, and these show a gain of 2458 labourers - 9845 natives being supplied, as against a wastage of 7387 due to expiry of contract, death, or other reasons.

The Chinese indentured labourers, 53,134 in number during October, show a decrease of 266 on the previous month. The net gain in unskilled labour during the month was therefore 2192.

The Premier Diamond Mine was very successful during October, washing 365,454 loads, and obtaining 112,478 carats, the yield thus being 0·31 carats per load.

At the meeting of the South African Association of Engineers held on November 7th, the paper presented at the previous meeting by Messrs. Leitch and Andrews, and dealing with the sewerage and storm water drainage in Johannesburg, was subjected to strong adverse criticism. The remarks of Mr. A. J. Edwards may be taken to be fairly representative, and these condensed were to the following effect. The chief drawback connected with the paper was, that it had been presented just three years too late; the writers' schemes should have been propounded before the works were taken in hand, considering the revolutionary nature of them. If works of this design were really practicable there would be a complete revolution in drainage construction, and even the theory and principles of drainage would have to be revised. The greatest innovation lay in the placing of the large storm-water pipes in the same trench with, and immediately above, the sewer pipes. At first sight this appeared to be a marvel of economy, because one trench cost less to excavate than two. In many of the streets of Johannesburg there was actually this saving initially, but there were also numerous cases where the foul drains could be laid at about half the depth below the surface of the road that they were now laid at. For instance, these sewers were placed in some streets at a depth of 12ft. and 14ft., where 6ft. or 8ft. would have been quite sufficient to obtain the required fall from branch and house drains. Because of the large sized storm-water pipes, and the necessity, owing to their great weight, of having a concrete bed and earth distance piece between them and the sewer pipes below, this led to an unnecessarily great depth of excavation, which work, of course, cost more per cubic unit as greater depth was reached. There was also the extra cost of the concrete bed for the storm-water pipes, and the very fact of its being thought necessary to lay this bed was an indirect admission that the superincumbent weight of the storm-water sewers was likely deleteriously to affect the pipes beneath. The virgin soil would have been quite good enough a bed for either system of pipes if laid separately. Granted that there was some saving of public money in the first instance by having only one trench, still, when owners of properties were compelled to connect at their own expense to the extra and unnecessary depth, they were not likely to appreciate the initial economy, and whether there would finally be any real saving over the whole system was quite problematical.

Regarding the efficiency of the new system, there was an adage, recognised by every engineer, whether of the old or modern school, that foul drains should be easily accessible. In the case of the system under discussion there would be no possible way of getting at the foul drain except through the storm-water sewer, and although there were manholes provided for this purpose, these manholes exceeded the limiting distance apart—viz., 200ft. Each of these spaces would also be a catch-pit from which stones and mud would have to be removed before the door of the manhole could be reached. No mention was made as to how the foul drain was to be cleared if a block occurred during rain, or even how in the dry season the block could be located. With this system it was impossible to provide for the usual lamp-holes to be placed between the manholes. The sewer pipes were of small size, designed to run full, and there could be no proper ventilation under these circumstances. The only fresh-air inlets were the 4in. openings in each manhole, and these had to supply in each case the whole of the fresh air to between 200ft. and 300ft. of main sewer as well as to about 500ft. of house drains.

Regarding the storm-water drainage, had these pipes been laid anywhere else than over the foul drains there would have been little discussion over the sewerage scheme of Johannesburg. However, in all other towns in this or any other country which are subject to torrential rains, storm water can be more effectively dealt with by open or surface channels. It was preferable to have only a few large storm-water sewers, these to be constructed in the roads to which most of the storm drainage converged.

JOHNSON SERVICE COMPANY, 249, Fourth-avenue, New York.—Tower clocks, clocks in systems, and programme clocks operated pneumatically, form the subject of this catalogue. The method of operating their tower clocks and clock systems is as follows:—A master clock is provided. This clock is the originator of the air movements which propel the works of the tower or other clocks. There is an air compressor—usually operated by ordinary city water pressure—to store up air at 10lb. pressure per square inch in a reservoir. To the dial movements of the tower or other clocks is attached a pneumatic motor. The compressed air is first conveyed to the master clock, and there, by peculiar mechanism, is sent on each minute, to the hands to be moved, through a suitable small pipe. Each time an impulse of air goes to the dial it moves the minute hand forward one-half minute and the hour hand proportionally. At the end of one-half minute the master clock releases the air and springs move the hand another half minute and so on.

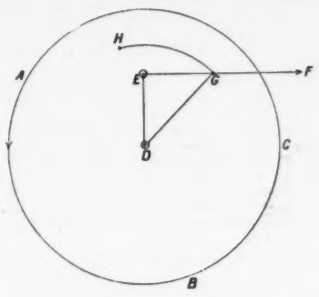
LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

A CENTRIFUGAL PROBLEM.

SIR,—My thanks are due to Professor Fitzgerald for his authoritative ruling on the subject of centrifugal force, thus clearing the ground of an embarrassing consideration. I quite admit the absence, on the part of the bicycle, of "centrifugal force," provided this term bears its usual interpretation, namely, the radially outward force which a body moving in a circle exerts, by virtue of its tangential velocity, on the connector which preserves constant the distance of the moving body from its centre of rotation. But I submit that if the meaning of the term is so limited, then there are other forces acting on the body which have escaped observation at the hands of your correspondents. The nature of these forces is most easily demonstrated by the following example :—

Let A B C be a disc rotating horizontally about its centre D with such a speed as produces a peripheral velocity V at the point E. Now, imagine that a small sphere, rotating with peripheral velocity



V, be dropped on to this moving disc at E. The sphere, then, by virtue of its originally impressed rotation, tends to roll forwards in the direction F, but is prevented from so doing by the equal and opposite velocity of the disc at the point of contact. Hence the sphere moves neither backwards nor forwards, and we have it on the authority of Professor Fitzgerald that it is not the subject of centrifugal force. But though admitting this, I claim that the sphere is nevertheless under the action of a force which is causing it to increase its distance from the centre of the disc, for, whereas the rotation of the sphere is causing it to move forwards in a straight line, the ground on which it moves is speeding under it circumferentially, and this latter circumstance is responsible for the movement of the sphere radially outwards from the centre of the disc. Such radial movement, accompanied as it is by an increase in peripheral speed of the disc at the contact point, results in the sphere being at the same time borne backwards.

That this combined movement actually takes place is easily proved. Imagine that the sphere, if the disc were stationary, would after the lapse of one second reach the point G—starting from E. When the disc is rotating, the point G in one second reaches the point H, the latter being a point on a circle passing through G—with centre D—such that $\frac{G H}{G D} = \frac{E G}{E D}$. Hence, under combined velocities of sphere and disc, the sphere at the end of one second arrives at the point H.

Clearly, then, the sphere is carried radially outwards from the centre and backwards, whether we assume the contact between the sphere and disc to be a point or an area. Were the disc provided with a rim, the sphere would press against that rim. This outward pressure is called into being solely by the circumferential restraint applied to a rectilinearly moving body. The same considerations apply likewise to a small sphere rotating round and within a larger sphere, itself rotating with such a velocity as to maintain the smaller sphere stationary, and it is only necessary to develop a sufficient velocity in order to maintain the smaller sphere supported at the top of the enveloping sphere, in spite of the action of gravity by the radial force thus occasioned. This radial force acts equally in the case of a bicycle travelling round an oppositely rotated sphere, and hence the feat originally proposed is possible.

I am aware that the forces which I have thus called into play act only on the wheels, and that the axles will have to support the vertical pull downwards due to the action of gravity on both cycle and rider. Centrifugal force being absent, all those parts not receiving adequate support from the axles must drop. Thus, the money will fall out of the pockets of the rider, his cap will fall off his head, his hair will stand on end, and he himself, unless he cling like grim death to handle-bars and toe-clips, will follow money and cap.

December 18th. A. B. C.

SIR,—Your correspondent "L. S. D's" modification of the original problem is easily explained. The resistance a cyclist has to overcome on a level road is threefold. First, the internal friction of the machine. Secondly, the rolling friction between the tires and the road, or belt in this case. Thirdly, the resistance due to cutting through the atmosphere. With the horizontal moving belt and stationary cyclist the third disappears, but the first and second remain. In the case of the inclined belt and stationary cyclist tending to ride up it, the first and second resistance remain to be overcome, and in addition the cyclist will exert the same power that would take him up a similar incline at the speed of the belt. This work will help to drive the pulleys round which the belt runs, and a dynamometer on the driving shaft, which might under the circumstances become a driven shaft, would show the effect of the cyclist on the inclined belt. As this inclined belt is only a special instance of the ordinary treadmill, I think "L. S. D." would get an emphatic answer to his question from our friend Mr. William Sykes if he asked him whether he does any work or not when "walking up the golden stairs."

May I, at the same time, add a word to what has already been said in your issue of 7th inst., as I see "X. Y. Z." has not grasped the explanations of your other correspondents. "A. B. C." apparently thinks that because motion is generally considered in the relation of one body to another, and that geometrically it is the same if the cyclist rides round the sphere or the sphere rotates round the cyclist, it follows that centrifugal force will appear in the second as it did in the first instance.

Properly to comprehend centrifugal force we must conceive the motion of a body or bodies merely in their relation to a point or position in space apart from their relation to any other body. Centrifugal force being an accelerating force, can only be exerted between two bodies or parts of a body whose centres of gravity are in motion and rotate relatively to some fixed point in space. This rotation may be simple, or combined with any other simple or complex motion. In the case of the rotating sphere and stationary cyclist it is clear that the centres of gravity of the cyclist and the sphere do not rotate as regards a fixed point in space, neglecting, of course, their somewhat complicated combined motion due to the path through the solar system of the point on the earth at which they are situated, and which we need not consider here, owing to its infinitesimal effect.

"X, Y, Z." is wrong, first, in assuming that there is any tendency towards motion of translation of the cyclist; and, secondly, that this tendency, assuming it to be there, would have the same or a similar effect to actual motion. Granted that the cyclist does gain his precarious position upside down inside the top of the sphere, he must actually move, or there will be no central acceleration, and, consequently, no sustaining centrifugal force; the mere tendency to move in a horizontal line tangential to the top of the sphere is not sufficient. Absolute motion of the cyclist except to gain his position at the top of the sphere was not in the hypothesis of "A. B. C.," and tendency towards motion of translation could only appear if there were a pressure between the cyclist and sphere to generate the necessary reaction of friction. Thus we should require the centrifugal force to produce the tendency towards tangential motion. The work done by the cyclist without it—before he falls—would be spent in overcoming the friction of the machine and producing rotary acceleration of the wheels.

December 17th. J. GRAY.

SIR,—If your correspondent "X. Y. Z." will consider what centrifugal force is, I think he will have no misgiving that the rotation of the containing sphere can affect the result in the case stated. In order that the cyclist shall safely complete the circuit without losing contact with the sphere, he must move with a velocity round its centre, such that, at the top—where the effect of gravity is a maximum—he would, if allowed to proceed in a tangent for a certain fraction of time, gain a distance from the centre equal to the distance gravity, would be able to pull him downwards towards the centre in that time.

With reference to the problem of "L. S. D.," the work to be performed by the engine while the cycle is running on the moving belt, and remaining stationary relatively to the earth, is exactly the same as it would be if the cycle were running on the same belt while at rest, the revolution of the wheels remaining the same, except, of course, the resistance due to travelling through the air. That is to say, the engine must do the work to overcome axle, and rolling, resistance.

In this country our roads are carried by the earth's rotation at a velocity of some 700 miles an hour. It would be rather fast riding, I admit, to counteract this, and the air resistance would be considerable, but apart from the wind it matters nothing whether one rides in a particular direction with or against the motion of the earth. In the case of the belt being inclined, the work is again the same as if the belt were at rest and the cyclist going up hill. In the case of the belt moving the cycle's work goes to help the belt to run, in the other the cyclist's position is raised.

It is only the case of the treadmill again. The losses by friction, &c., are identical whether the man remain fixed relatively to the earth or walks upstairs. GEO. M. SEABROKE.

Rugby, December 17th.

SIR,—"X. Y. Z." puts the matter clearly when he assumes the question at issue to be whether or no the effect of the cyclist's "effort is to tend to move him in a straight line tangential to the sphere at its highest point, *i.e.*, to increase his distance from the centre," but he is in error in stating that we "seem to have missed the real point at issue," for it was this very point I attempted to investigate by the two cases I instanced, namely, the moving platform and the disappearing sphere.

Does "X. Y. Z." maintain that in either of these cases the cyclists would not come to rest? If he agrees with me that they would come to rest, then my point that there is no tangential velocity is proved; if he considers that they would not come to rest, then, perhaps, the following considerations may be of use :—

Suppose an open truck to be moving on a railway at the rate of 10 miles an hour, and two balls are let fall from above, one to fall to the earth at the side of the truck and the other to fall on the truck. The one that falls on the earth will at once come to rest; the one falling on the truck would strike anyone standing on the truck with a force equivalent to that exerted by a ball moving at the rate of 10 miles an hour. Again, if the person standing on the truck threw a ball at the rate of 10 miles an hour in the opposite direction to that in which the truck is moving, the ball would, on reaching the ground, remain at rest.

The great point is to see clearly that there is only centrifugal force when the cyclist is moving round the centre of the sphere; as soon as there is no movement round the centre, then there is no centrifugal force.

December 18th. C. T. P.

SIR,—I was rather surprised to see "A. B. C.'s" problem brought up again, but it may still puzzle some people if taken with the problem presented by "L. S. D."

I should say that a cyclist, when stationary relatively to the earth on a moving, inclined track, which tends to carry him downwards, is undoubtedly doing work beyond overcoming the friction of his bicycle. This work goes to help the motor which moves the track, just as his weight would if he stopped pedalling and allowed himself to be carried down.

The same would happen in "A. B. C.'s" case—supposing the cyclist to start at the bottom of the sphere and ride up—till he got to a place so steep that the grip of his wheel would not be sufficient to prevent skidding. Beyond that point centrifugal force is necessary, and when it is remembered that this force is only an application of Newton's first law, it is obvious that it needs actual and not relative motion. ARNOLD MAUDE.

Great Baddow, Chelmsford, December 17th.

SIR,—Your correspondent "L. S. D.," whose letter appeared under the heading of "A Centrifugal Problem" in the issue of the 14th inst., states that in his opinion if a motor cyclist be travelling on a horizontal belt which moves at the same rate as he, but in the opposite direction, so that the motorist's velocity relative to other things is zero, his engine performs no work beyond that required to overcome the internal friction of the machine. But, surely, if his engine supplied no more power than that necessary to overcome this friction, the machine would move backwards in the direction of the motion of the belt. Therefore, work must be done to check this tendency towards backward motion, *i.e.*, to maintain the motor cycle at the same point on the belt.

December 17th. ROY L. DREW.

SIR,—None of the three answers of your correspondents establishes in a scientific manner the point in question, that the cyclist of Mr. "A. B. C." cannot remain fixed at the top of the sphere if he is motionless relatively to the audience; or—what is the same—to the axis of the sphere.

Every engineer knows that if—

r = radius described by the centre of gravity of a body—here the cyclist + the cycle,

m = mass in rotation,

w = angular velocity, the value of the centrifugal force (C) is :—

$$C = m \cdot w^2 r.$$

If, for any reason, the cyclist ceases his motion round the sphere axis $w = o$, consequently $C = o$.

When $C = o$ the cyclist is only attracted by the force of gravitation, and will fall to the bottom of the sphere.

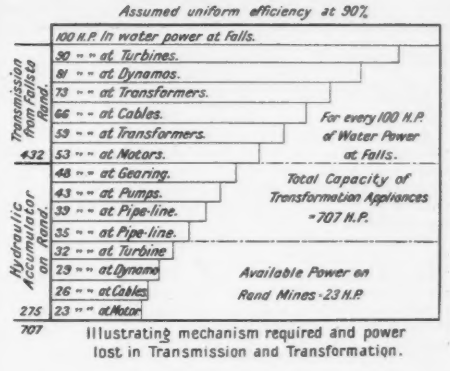
December 11th. ANDRE E. LANGER.

TRANSMISSION AND TRANSFORMATION OF ENERGY: THE VICTORIA FALLS SCHEME.

SIR,—I remember seeing in my early days a manganese mill driven by a water wheel. The water for working the wheel was pumped from the tail-race of the wheel by means of a Newcomen steam engine into a pond, from which the wheel took its supply. The combination formed a means of transmitting and accumulating power, for it is obvious that the engine might be kept pumping whilst the mill was idle. I see that such a system is proposed for working the machinery of the mines in South Africa. Turbines at the Victoria Falls—700 miles away—are to pump water into a pond on the Rand, from which the Rand mines are to take their power by means of other turbines and motors.

In my youthful wisdom I looked on the Newcomen engine and water wheel as a rather clumsy and expensive scheme, but in my mature age I ask myself whether, in our anxiety to do everything through the medium of electricity, we do not often propose, and sometimes carry out, more imperfect engineering work.

In driving the manganese mill the losses due to the indirect method of driving were in the pumps and water wheel; that is to say, there were two tranformations in the transmission. Each transformation, of course, causing a loss of energy. I find in the Victoria Falls scheme that there are no less than fourteen transformations, each representing a loss of energy. The losses are not the same percentage for each transformation, and I shall not attempt to estimate what each individual loss would be. For the sake of illustrating my argument, I will assume a uniform efficiency of 90 per cent.; not a low efficiency for things generally. On this assumption every 100 horse-power taken from the Falls will dwindle down to 23 horse-power at the consumer's premises on the Rand mines, and the total power represented by the various appliances employed to produce that result would be 700 horse-power. This is shown clearly on the accompanying diagram. It is true some of the power would be distributed at the sixth stage—see diagram—with a corresponding advantage; but the value of the scheme as a commercial undertaking must be based on the total cost of the whole, plus the working expenses. Leaving out of consideration the working expenses, which would be necessarily


Power Diagram.
Assumed uniform efficiency at 90%.
100 H.P. in water power at Falls.
90 " " at Turbines.
81 " " at Dynamos.
73 " " at Transformers.
66 " " at Cables.
59 " " at Transformers.
53 " " at Motors.
48 " " at Gearing.
43 " " at Pumps.
39 " " at Pipe-line.
35 " " at Pipe-line.
32 " " at Turbine
29 " " at Dynamo
26 " " at Cables
23 " " at Motor
Transmission from Falls to Rand.
Hydraulic Accumulator on Rand.
432
275
707
For every 100 H.P. of Water Power at Falls.
Total Capacity of Transformation Appliances = 707 H.P.
Available Power on Rand Mines - 23 H.P.

Illustrating mechanism required and power lost in Transmission and Transformation.

very considerable, the great cost of the undertaking, compared with the net result, would in itself make the game not worth the candle. Long distance electric transmission is very interesting, but it is only of practical value when it returns to the investor a fair interest on the money invested.

My object in writing this letter is to point out that the adoption of up-to-date notions, like change in fashions, often leads to expenditure incommensurate with the advantage derived, and I only use the Victoria Falls scheme as an illustration to show how much energy and hard cash one can fritter away by transformations. I do not think that the commercial value of the scheme has had the practical consideration and investigation which should be given to an undertaking for which the public are invited to provide so much money. HENRY DAVEY.

Westminster, December 15th.

THE VICTORIA FALLS POWER SCHEME.

SIR,—If storage on the Rand is to be a feature of the proposed scheme for utilising the power of the Zambesi Falls, may I point out that it would involve a very much smaller capital outlay, and would give a very much higher efficiency, if electro-thermal storage was employed in place of the hydraulic. I need hardly remind your readers that heating by electricity has been developed very largely in many directions during the last ten years, and that its efficiency is very high. I think I should hardly err on the wrong side if I took the efficiency of a system of electro-thermal storage as 80 per cent., while that of hydraulic storage could hardly exceed 50 per cent. As it should be possible to raise the temperature of a body of water, under the conditions that would rule, some 250 deg. Fah., I make out that where some 1600 million gallons of water would be required with the hydraulic system for a storage of 50,000 horse-power for twelve hours, a quantity of water that could be carried in a battery of Lancashire boilers would answer with the electro-thermal system. I need hardly remind your readers that thermal storage has been successfully carried out on the system introduced by Mr. Druit Halpin and Professor Rateau, using steam as the source of heat, and that it is a short step from that and from existing electro-thermal apparatus to the one I suggest. It is quite true, of course, that details will have to be worked out, and the idea may possibly come as a little startling to those who have not considered the matter, but it is hardly more startling than the proposal to deliver the energy of a waterfall at a distance of 700 miles on to a coalfield, and the details that will have to be worked out, I venture to say, will not be so difficult as those involved in delivering the large amount of power named over 700 miles at 150,000 volts.

SYDNEY F. WALKER.

Bath, December 17th.

PERKINS' BOILER.

SIR,—I have read with much interest Professor H. J. Spooner's letter in your issue of the 14th inst., and should like, with your permission, to make a few remarks thereon.

The drawing shown is of a boiler which was specially designed to take the place of one of the ordinary marine fire-tube type, and to work at a pressure of from 400 lb. to 500 lb. per square inch.

The standard Perkins boiler was somewhat differently arranged, the heated gases rising vertically and impinging against a series of horizontal water tubes on their way to the uptake.

As mentioned by Mr. Spooner, a vital principle of the Perkins system was that distilled fresh—not distilled sea-water—was used for feeding the boiler, and when this was strictly adhered to no incrustation took place. The use of Perkins' patent metal piston rings obviated the necessity for any lubricant in the cylinders, and consequently no oil or grease passed into the boiler from the condenser. LOFTUS PATTON PERKINS.

Cricklewood, N.W., December 15th.

A GRAPHIC WATER RECORDER.—In our last issue, when describing the Lea graphic water recorder, we gave the address of the maker—Mr. James Lea, B Sc.—as 40, Brown-street, Manchester, instead of 46, Brown-street, as it should have been.

TRANSFER STATION AT HANNOVERSCH-MUENDEN

TRANSFER STATION AT HANNOVERSCH-MUENDEN.

A TRANSFER station has recently been opened at Hannoversch-Muenden. It is intended to form a new connecting link between waterways and railways, and is expected to restore to the city of Muenden, which was for centuries the chief commercial emporium on the Upper Weser, the traffic of former times.

It may be said that after the opening of railways the once flourishing transfer traffic of Muenden gradually declined, while the importance of Weser navigation at the same time decreased in proportion. Latterly, however, a number of improvement works have been carried out in the river, and schemes for connecting the waterways and railroads have been discussed. However, it was not before the month of May, 1905, that the construction of the transfer station shown in the accompanying engraving was commenced under the auspices of the North German Lloyd. The following is a short description of the plant just completed.

The transfer station proper is situated on the right bank of the river Weser, between stations 0 and 0·3 of the latter. The level of the loading and unloading tracks is situated at the same height as the maximum navigable water level, which as an average is exceeded only twice each year, and nearly always when but little traffic is being carried on. On the river side of transfer station there is a quay wall 240 m. in length, which can accommodate four large Weser barges. The front surface of the quay wall is inclined at an angle of 1 in 10—that is to say, is nearly vertical. It has been provided with anchorings and bollards at distances of 21 m. each at two levels, while four ladders are arranged in niches along the wall.

The quay has three sets of railway lines parallel to one another, and connected together by crossover roads.

The lower part of the transfer station contains a storehouse which comprises two storeys, each having a useful area of 650 square metres. These two storeys are partly carried on arches, as will be seen in the engraving. The lower storey is calculated for a useful load of 1000 kilos., and the upper storey for 800 kilos. per square metre. Each storey, in addition to numerous windows, has four openings closed with roller shutters. In front of the openings of the lower storey there runs a continuous platform 1·5 m. in width, while narrow platforms are provided in front of the upper doors. The storehouse, in addition to serving as a means of transfer between railway and canal, also deals with the horse-hauled goods on the Goettingen high road, transferring them either to railway or canal, and *vice versâ*. The floor of the upper storey has for this purpose been made about 1 m. higher than the road. A trolley travels from one of the doors facing the water to a loading platform on the high road.

The transfer of goods between vessels, railway trucks, and the storehouse is effected by means of an electrically operated gantry jib crane, which can move on two rails, one of which rests on the quay wall and the other on a projection of the storehouse.

Adjoining the storehouse there has been provided a building, in the lower storeys of which are situated an accumulator room and engine-room. The latter contains a gas engine and dynamo with the necessary auxiliary apparatus. Above the engine-room are situated the offices, and above the latter are dwelling rooms for the machinist. Special care was taken with the architectural design of the storehouse and adjoining building, in view of the beautiful scenery on the banks of the river in the midst of which the plant is situated. The railway leading to the storehouse is connected to the State Railway system. On the branch gradients of from 1 to 60 to 1 to 77 are met with.

THE INSTITUTION OF CIVIL ENGINEERS.

PAPERS ON WATERWORKS.

AT the ordinary meeting on Tuesday, November 27th, at 8 p.m., Sir Alexander Kennedy, LL.D., F.R.S., President, in the chair, three papers were read, namely, "The Talla Water Supply of the Edinburgh and District Waterworks," by W. A. P. Tait, B.Sc., M. Inst. C.E.; "Repairing a Limestone-Concrete Aqueduct," by M. R. Barnett, M. Inst. C.E.; and "The Yield of Catchment Areas," by E. P. Hill, M. Inst. C.E. The following are abstracts of the papers:—

The first paper deals with the new supply lately introduced from Talla, one of the head waters of the river Tweed, and occasion is taken to review shortly the other proposed sources of supply which for a time were under consideration. Attention is directed to the results of borings and trial pits at other sites which were considered, viz., St. Mary's Loch and the Manor Valley A statement is given of the population and water consumed for domestic and trade purposes in 1870 and at the present date.

Attention is directed to various points in the Act authorising the construction of the Talla Works. For instance, there was some diversity of opinion as to the available rainfall. The steps taken to appoint arbitrators to determine this and the subsequent amount of compensation water are dealt with. The basis upon which the arbitrators proceeded in considering and issuing their award is fully placed before the Institution, and it is also mentioned that the Water Trustees, though only bound by their Act to have rain gauges read during a period of seven years, have adopted a suggestion made to them by the arbitrators, that the readings of these gauges should be continued. The author points out that it might have been more satisfactory if the clause appointing the arbitrators had provided for regular readings of gauges on the stream as well as ordinary rain gauges, and the paper goes on to refer to a series of observations which have been made during the filling of the reservoir with a view to determine the relationship between actual and available rainfall on this drainage area.

The opposition by the river Tweed Commissioners and the proceedings in the subsequent arbitration with them are also noticed, and the award by the umpire is stated.

The general features of the valley in which the Talla reservoir is placed are described, and some drawbacks to Talla as a really good reservoir site, including the total absence of suitable clay for puddle and of good building stone, are referred to. A general description is given of a railway, 10 miles in length, which was constructed to the reservoir from the nearest point on the Caledonian Railway, for bringing up clay, building materials, &c.

The general design of the reservoir embankment and puddle trench is described, and some drawbacks to Talla as a really good reservoir site, including the total absence of suitable clay for puddle and of good building stone, are referred to. A general description is given of a railway, 10 miles in length, which was constructed to the reservoir from the nearest point on the Caledonian Railway, for bringing up clay, building materials, &c.

The general design of the reservoir embankment and puddle trench is described, and some changes in the design, which were brought about by various causes, are referred to. Mention is also made of the timely discovery that water was escaping outside the lining of the outlet tunnel from the reservoir. The probable cause of this, and the method of preventing subsequent leakage, are dealt with.

Particulars are given of the outlet works and of the gun-metal valves which were adopted.

A general description of the aqueduct is given, and various troubles encountered in its construction are related. The method of timbering adopted in some of the soft tunnels is described. For one of the tunnels recourse was had to compressed air without a shield, and the process of driving and the plant used are described.

The paper concludes with a statement of the cost of the work, and also statistics of the Edinburgh and District Water Trust's rating and revenue.

To it are appended tables of the rainfall on the Talla drainage area for ten years, and also a series of gaugings of springs extending over forty-three years.

The second paper describes the work of repairing a short length of the Thirlmere aqueduct which conveys water from Thirlmere, in the Lake district, to Manchester.

The aqueduct, which is nearly ninety-six miles in length, was completed and brought into use in October, 1894. After the water had been flowing through the aqueduct for a number of years, it was found that the full quantity of water was not being received at Manchester, and one of the causes was that considerable leakage was taking place in the concrete culvert portion of the aqueduct at Hutton Roof—a length of nearly three miles. For several years repairs were carried out in this length, but these did not stop the leakage, as it was found that the leakage began at new places. The author, who had been resident engineer in the same district during the original construction of the Thirlmere aqueduct, and had returned in connection with the laying of a second line of pipes, was requested to investigate this matter and carry out the necessary repairs.

The first work done was to re-test the length in question, in order to locate the leakage. This was done by fixing timber stanks across the culvert at the manholes. These stanks were made with a rectangular opening, large enough to pass the water through to Manchester, but which could be closed with a wooden door during the tests. The main divisions were further subdivided into 4-chain engths and tested. The tests proved that there was a total loss of over 1¼ million gallons of water in 24 hours, when the aqueduct was running full, and also indicated where the leakage was occurring and its relative extent in the several sections.

The work of repairing was started in the section at the north end, where the leakage was found to be greatest. On making an examination of the concrete in this length, the author found that the cause of the leakage was due to the action of the soft water from Thirlmere on the limestone in the concrete of which the Hutton Roof section had been built. Holes were found in the floor of the culvert by which the water was escaping, and all the small individual pieces of limestone were found to be much water-worn.

Analyses of the water in the Thirlmere aqueduct are given.

The author made experiments to ascertain the rate of the action of the soft water on blocks of the limestone, and the Portland cement and mortar—one of cement to one of sand—used for the repairs, were similarly tested. Chemical analyses were made of the limestone from which each of the blocks was prepared, as well as of the Portland cement and the sand, and the results of these tests and analyses are given.

After three months' immersion the rate of wastage of the blocks varied from 6·83 per cent. per annum to 18·10 per cent. per annum, and after six months' immersion from 6·75 per cent. per annum to 17·09 per cent. per annum. The sample blocks of Portland cement and mortar, instead of losing, actually gained slightly in weight, namely, the cement block 5·47 per cent. per annum and the mortar block 3·57 per cent. per annum.

It was decided that the whole water surface of the concrete in which limestone had been used should be re-faced with Portland cement mortar not less than 1in. in thickness. The methods adopted in removing the necessary thickness from the old concrete and in applying the new mortar facing are described in detail. The mortar was put in between timber framework fixed so as to give the correct thickness and maintain the original dimensions of the culvert. The surface of the invert was hacked off and re-plastered after the side walls had been done.

A description is given of various special circumstances arising during the execution of the repairs and of the nature of the various holes, &c., met with. Although the removal of the surface of the concrete in the culvert was a very searching test, the whole of the concrete in the Hutton Roof section of the aqueduct was found to be excellent in quality, as far as the workmanship was concerned, and could not be improved upon in this respect.

The way in which the outside water was dealt with is described. In all cases free vent was given to the water by the insertion of pipes of suitable diameter, and these were carried up the side walls to above top water-level.

The author of the third paper points out the deficiency of data for computing the yield of drainage areas for waterworks purposes, and the necessity for such data in utilising the areas in the most economical manner, having in view the few suitable areas yet remaining unappropriated.

Reference is made to the difficulties encountered in making stream gaugings on a large scale and recording the observations continuously. The present method of estimating the yield by rainfall observations, combined with assumptions as to loss by evaporation, and rate of flow in the streams, is next described.

Finally, the author urges the necessity for every waterworks being utilised as an experimental station, and for water authorities keeping an account of water received and expended, like a banking account, as a condition of their being allowed to appropriate a portion of the national sources of water supply.

HIGH-TENSION SWITCH GEAR.

AT the ordinary meeting on Tuesday, December 18th, Sir Alexander Kennedy, LL.D., F.R.S., President, in the chair, the paper read was "Mechanical Considerations in the Design of High-tension Switch Gear," by H. W. E. Le Fanu. The following is an abstract of the paper:—

The principal points considered in this paper are those connected with the mechanical arrangement and details of modern high-tension switchboards. Among these points are the sub-division of the gear into different self-contained compartments to receive the various apparatus connected with the several departments of the supply, such as the circuit-breakers, bus-bars, section-switches, instrument transformers, &c. A special method of securing compactness in switchboards with spaciousness for the compartments is described.

The sub-division of control, so desirable in a modern station of large output, is considered, and suitable arrangements to secure this are described.

Descriptions are given of a special form of high-tension oil circuit-breaker, together with the methods adopted for operating the same manually or by electric control, and the necessary safety devices employed.

The paper also deals with the general arrangement of the various bus-bars for the main supply, for excitation, and for cable-charging, &c.

PASS LIST, OCTOBER EXAMINATIONS, 1906.

Studentship (59).—F. J. Ainsley, H. S. Aldred, W. C. Ash, G. H. Austin, E. H. Beal, R. H. Blackburn, N. S. Bowes, W. H. Brown, A. Carr, E. F. Chacksfield, J. H. Crossley, W. O. Cudworth, C. H. Dobson, P. Dougall, T. H. Edwards, K. A. P. Field, S. S. Frank, W. Froggatt, O. G. Furnivall, A. E. Griffiths, C. W. Griffiths, B. C. Hammond, J. A. Headly, F. C. F. Heley, C. F. Hemingway, G. W. Hilliard, B. B. Horsbrugh, A. C. Howard, F. W. Ireland, E. W. Izard, G. V. W. Jones, A. O. Knight, C. G. Newhouse, J. A. Orrell, J. F. R. Peebles, V. C. Peycke, J. A. F. Powell, S. Reason, F. S. Robinson, M. H. Sears, J. B. Snape, H. H. M. Spink, A. C. Swales, A. W. J. Symes, F. Tait, H. Terrell, G. B. Thompson, S. G. Thompson, P. K. Turner, S. E. Tyrwhitt, P. A. Watford, H. C. Whitehead, R. H. Whitfield, J. Wilde, E. J. Willis, R. J. W. Wilson, A. E. Wood, S. L. Wright, R. R. Yerburgh.

Associate Membership (156): (a) *Candidates examined in London* (136): *Whole examination* (83).—A. C. Anderson, B. F. Beverley, O. H. M. B. Beyer, S. H. Bigsby, R. Blackburn, J. Boothroyd, F. C. R. H. Boyd, E. R. Briggs, E. P. Burke, A. Burridge, J. P. J. Butler, R. W. Butler, W. F. Byrnes, A. V. Clarke, J. W. C. Coates, R. H. Collins, C. B. Connell, W. H. A. Court, F. G. Cox, H. T. Creasy, A. Croad, M. H. Curry, R. T. Deane, F. W. Dowley, A. D. Draper, J. N. Ellis, F. D. Evans, A. McA. Finlayson, R. Gilchrist, M. Gimson, F. C. Griffin, A. J. Hall, T. Hare, C. P. M. Harrison, F. G. Helsby, H. Hughes, A. B. Joscelyne, W. Keay, C. G. Kent, R. Kilner, F. C. P. Laurence, J. S. S. Lee, R. T. McCallum, J. W. McKerrow, P. H. Maflin, E. L. Manley, N. R. Mohindar, G. M. Moore, V. Parlby, J. E. Parr, F. T. Patterson, A. Pope, F. A. Primrose, D. W. J. Ravenhill, J. O. Rennie, A. A. Richardson, F. E. Robinson, L. R. Ronald, J. L. Sale, W. H. Shortt, H. C. Sims, F. W. Slane, R. Snodgrass, J. H. Sullivan, G. N. V. Thompson, F. W. Timmis, G. G. T. Toller, T. F. Tomlinson, P. W. Turner, S. B. Tyabji, F. M. Wainwright, W. H. Wainwright, F. H. Walker, J. F. E. G. Walker, R. Watkin, D. T. Wells, C. G. Wellsted, J. Wibberley, W. L. Wilkinson, G. S. Wilson, L. T. Wilson, A. Woodhead, E. P. Wooldridge.

Section B of Part II. (28): (*previously passed in Part I. and Section A of Part II.*).—F. W. Anderson, W. Beloe, R. A. Bentall,* E. V. Blomfield, H. M. Dobree, D. Edwards, H. A. R. Edwards, J. L. Elder, C. R. S. Farmer, J. Fletcher, L. M. Foulkes, V. Gordon, R. F. Hall, W. D. Harding, H. H. Howell, C. H. Hutchinson, E. E. Lloyd, A. C. Maclean, E. S. Northcote, E. H. Parry, T. O. Pepper, S. G. Plante, H. E. Robarts, T. M. Scully, E. W. F. Smith, E. H. van der Straaten, H. C. Swayne, W. I. Tait.

Part I. and Section A of Part II. (25).—P. M. Battle, F. J. von Bock, E. R. Branston, W. MacG. Cargill, W. N. Cartland, M. C. Chalart, J. M. S. Culbertson, J. Diggle, R. M. Francey, W. H. Gorton, G. B. G. Hull, L. W. Jameson, G. I. Jones, J. McDonnell, F. May, F. J. Mills, S. M. Oborn, J. G. Powell, C. H. Roberts, H. S. Saunders, T. A. Shaw, V. G. H. Smith, J. L. Travers, J. R. Webb, jun., H. S. Wilkinson.

(b) *Candidates examined abroad* (20): *Whole examination* (15).—H. E. Coad, W. R. Davidson, W. Farrant, W. M. Griffith, J. E. Hensman, D. P. Howells, H. R. Hyatt, C. R. Jones, J. McLean, D. H. Remfry, T. C. Rose, H. J. T. Smith, W. R. Wilson, J. Wood, H. J. Young.

Section B of Part II. (5) (*previously passed in Part I. and Section A of Part II.*).—C. D. Gee, C. W. Harris, N. R. Lyth, W. G. Melvin, G. H. Whitehouse.

Since deceased.

THE TRIALS OF SUCTION GAS PLANTS, AT DERBY 1906.

As promised in our last issue, we now give, with some omissions, the first part of Captain Sankey's report on the trial of suction producer plants at Derby. The principal tables were given last week.

The combination known as a suction gas plant, in which a gas engine provides, by means of its suction stroke, the draught necessary to make the fuel burn in a producer, is of very recent origin. As regards the Royal Agricultural Society, the first exhibit was made in 1901 at Cardiff by Messrs. Crossley Brothers, Limited. Then at the 1903 show at Park Royal a suction gas plant was exhibited by the Dowson Economic Gas and Power Company, Limited, which was a combination of a Dowson producer with a National gas engine. Messrs. Crossley Brothers, Limited, also exhibited a suction gas plant at this show. At the 1904 show three such plants were entered, and at the 1905 show the number had increased to four.

This increase in exhibits of suction gas plants, together with the claims set forth by the makers in respect of the reliability and economy of such plants, was mainly responsible for the decision to hold the trials now being reported on. The response of the makers was beyond expectation. Fourteen plants were entered for trial and many others were exhibited. All the fourteen plants started on Monday morning, June 18th, but three of them were withdrawn during the trials. The list of the competing plants is given in Table I.

OBJECT OF THE TRIALS.

Regarded from the point of view of the Royal Agricultural Society, the object of these trials was to determine, so far as a series of trials extending over one week would permit, whether suction gas plants could be relied on to work for agricultural purposes, day in and day out, with the same degree of freedom from breakdowns as a steam engine, and with the same small amount of attendance as is required by an oil engine. Satisfactory answers to these questions would prove the suitability of such plants for agricultural purposes, because there is no doubt as to the great improvement in fuel economy, as compared with either a steam or an oil engine of the same power.

One of the most important factors in judging the merits of the various plants was the fact that these combinations of producers and engines would, in many cases, be placed in the hands of agricultural labourers, to whom very little discretion could be given in mechanical matters; and, therefore, means of adjustment intended to obtain some small economical advantage would not be of the same value as when in the hands of a skilled attendant.

The size of plant fixed upon for trial was from 15 to 20 brake horse-power, this size being suitable for threshing and other agricultural purposes.

DISCUSSION OF THE REGULATIONS.

The principal regulations issued by the Society, under which the trials were carried out, were as follows:—

1. The plant to consist of gas generating plant and engine, complete, of 15 to 20 brake horse-power as a maximum.

2. Each engine must be fitted with a rope or web brake on the fly-wheel, water trough in wheel for cooling, indicator cock and gear, revolution counter and explosion counter, to be approved by the Society's consulting engineer. Water will be found by the Society.

3. One attendant must be in constant charge of each plant to give any information which the judges may require. Any attention actually given by him to the working of the plant will be noted.

4. Each exhibitor will declare at what brake horse-power he intends to run his engine for the full load trial, and no variation therefrom beyond 5 per cent more or less will be allowed.

5. Full load, half load, and light or no load trials will be made with uniform selected anthracite coal provided by the Society. A subsequent full load trial will be made with coke as fuel. Each plant will be started from cold on the full load trial. The first full load trial will be commenced with the gas generators empty.

6. A given quantity of coal will be weighed out to each competitor, the time of lighting up will be noted, and so soon as sufficient gas has been generated and the engine is running at full power the time will be taken. This time will be recorded as the commencement of the run, so far as fuel consumption is concerned.

7. The engines will run for nine hours under constant load, after which they will be shut down for the night, and will resume running on the following day. At the conclusion of the trials the fires will be drawn, and any unconsumed coal will be weighed back and credited for what it may be worth.

8. The half load trials will be conducted on precisely the same lines as the full load trials, with the exception that they will be of shorter duration.

9. The light or no load trial will be of two hours' duration. No coal consumption will be recorded for this trial. No working of the fan by hand will be permitted during the half load and light or no load trials.

10. On the completion of the above trials, one full load trial of nine hours duration will be made, using coke as fuel.

11. The points to which special attention will be directed are:—
(1) Attendance necessary.
(2) General design—including facility of cleaning—and space occupied.
(3) Regularity of working.
(4) Fuel consumption. Water consumption.
(5) Price.
(6) Relative proportions of gas producer and engine.
(7 Volume swept by piston relative to brake horse-power.

Before proceeding to a description of the plants and of the trials carried out, it is desirable to make a few remarks on these regulations, in order to indicate the general considerations which guided the judges in the inquiries and observations they made during the trials, and in making the award.

In the first place, it is to be borne in mind that it was the combination of producer and gas engine that was being judged, the former, however, owing to its comparative novelty, requiring most attention and criticism. It may also be pointed out that with two exceptions the engines themselves were of the usual horizontal type, and embodied the results of the long experience of the various makers.

(1) *Attendance necessary.*—An important distinction must be drawn between the attendance required for starting the plant and that needed for looking after it when running, that is, for attending to the lubrication and for filling the hopper with coal. Should additional help be needed at starting for turning the fly-wheel, little or no additional expense is incurred. During running only one attendant is needed at most, and if the plant is quite reliable, it can in many cases be left to itself for comparatively long periods, and the attendant can perform other duties during such periods. The attendance required during running is thus in a measure dependent on the regularity of the working or reliability of the plant. Some of the engines were fitted with self-starters—see Table I.—and it is clear that, with engines of the size under trial, the only gain is to save the small expense above referred to for starting, whereas extra complication and chances of failure are introduced by the starting apparatus itself.

(2) *General design, including facility of cleaning, and space occupied.*—A simple straightforward design is the desideratum. Since the main lines of the design of the gas engines were, except in two instances, common to all, the details were the points which had to be most carefully considered. As regards the producers, they followed closely the lines of the "Dowson" producer, and, therefore, differences were investigated, and they were principally confined to arrangements aimed at reducing the difficulties caused by clinker, to means of regulating the air and water supply, and for increasing the regenerative effect of the suction producer. Hard water may cause trouble by "scaling," and this is a matter of great importance; but the relative immunity of the various producers in this respect could not be tested in the short time available, and therefore could only be gauged by general considerations. The design of the plant in respect of provision against possible escape of poisonous gas or risk of explosion required careful consideration.

The suitability of the design for manufacturing on the interchangeable system comes under this heading. It is a specially important matter for agricultural engines to ensure that spare and repair parts shall go into place without fitting.

The regularity of running when using coke as a fuel depends on the amount of tar deposited on the valve seats. In the present state of the art no adequate provision can be made in the producer for preventing the formation of tar if the coke contains it in any material quantity. The ease with which the valves can be got at and cleaned is, therefore, of more than usual importance, and much stress was laid on this point. In this connection it is well to point out that gas coke varies considerably in regard to its freedom from tar, and it is to be hoped that when suction gas plants become more general an arrangement will be made whereby some standard of permissible percentage of tar can be ensured. The following points also come under this section:—Ease of dismantling connecting-rod and piston, also main bearings; the method of attaching the cylinder to the frame; the various important scantlings, especially those of moving parts; the material used and the workmanship, especially with regard to interchangeability; the lubrication of the bearings, of the cylinder, and of the piston.

No comment is needed as regards the space occupied.

(3) *Regularity of working.*—Apart from the effect tar has on the valves, as already pointed out, the majority of the engines can be relied upon for working with a minimum of trouble, as judged from previous long experience with town gas and pressure producer gas. The suction producer is, therefore, that portion of the plant which required most attention. The gas is only made as required, and when working for any length of time at a particular load the conditions in the producer will adjust themselves to that load. If a sudden and considerable change of load then occurs, the producer will take a little time to adjust itself to the conditions required by the new load. The rapidity with which a suction producer will readjust itself is of considerable importance. A change from light load to full load is the most severe, because in this case the quality of the gas is poor and it is unable to give the power. In the reversed change of load the governor takes charge. Special provision has to be made for dealing with prolonged periods of light load, as, for instance, having a by-pass through which a portion of the gas is blown to waste each stroke; otherwise there might not be sufficient suction to keep the fire alight. A special trial was framed to test the capabilities of the producers to respond to changes of load based on the light or no load trial in the regulations (Regulation No. 9).

(4) *Fuel consumption.*—Owing to the conditions of running of these plants it is important to know the fuel consumption, including the amount burnt at night when the plant is standing. The general practice in the case of an engine doing constant work is to light the fire on Monday morning, bank the fire during the night, and only draw it on Saturday to clean out the producer. This practice was kept in mind when arranging the trials.

Although anthracite can be obtained in most districts, it is easier to get coke, and, apart from the difficulty already mentioned in connection with tar, it will generally prove to be a cheaper fuel, notwithstanding the greater weight consumed. The coke trial was therefore of special importance.

It was borne in mind that in the case of these plants the cost of fuel is relatively far less important than in the case of a steam engine, because in the former from 1 lb. to 1½ lb. of coal or coke is required per brake horse-power hour, whereas in the case of non-condensing steam engines of a suitable class for "estate" engines from 5 lb. to 6 lb. are needed, and with small condensing engines about 3 lb.

The water consumption and the last three points require no comment.

These regulations seem to cover all the essential points for consideration in trials of this nature.

The arrangement of the fire-brick lining of producers is an important matter, as it has a considerable effect on the formation of the clinker, on the liability of the clinker to adhere, and on the ease with which the clinker can be removed. Further, if the interior is difficult to get at, the lining with fire-brick is likely to be badly done by the bricklayer, and there will be defective joints, which will let in air and produce intense heat in the vicinity of these joints, and thus spoil the brickwork and produce clinker. In the hoppers, by means of which the fuel is fed into the furnace, there are variations in the design of the valves which are required for connecting the hopper with the furnace and with the outside, respectively, when fresh fuel has to be put in. This detail is important, as it is essential that no air should be able to find its way into the producer *vid* the hopper, and this detail has therefore received considerable attention from designers. To maintain good gas, the depth of the fuel in the furnace should not vary sensibly, and for this object it is usual to have a storage bell which also acts as a distilling chamber, from which the volatile

TABLE I.—*Particulars of Suction Gas Plants Submitted for Trial.*

Number in catalogue.	Name and address of exhibitor.	Catalogue B.H.P.	Name of producer.	Name of engine.	Revs. per min.	Stroke.	Diameter of cylinder.	Declared B.H.P. Anthracite.	Declared B.H.P. Coke.	Price of plant (declared).	Price per declared B.H.P. Anthracite.	Price per declared B.H.P. Coke.	Remarks.
						In.	In.			£	£	£	
7	The National Gas Engine Company, Limited, Ashton-under-Lyne	20	National ..	National ..	190	18	10	20	20	233	11·65	11·65	
8	Railway and General Engineering Company, Midland Engineering Works, Nottingham	20	Dowson ..	Railway & General	170	18	12	20	20	199	9·95	9·95	Compressed air self-starter
9	Davey, Paxman and Co., Standard Ironworks, Colchester	15½	Paxman ..	Paxman ..	220	15	9½	15·5	15·5	210	13·55	13·55	Three-step hit-and-miss governor. Paxman's patent timing apparatus. Compressed exhaust gas self-starter
11	The Dowson Economic Gas and Power Company, Limited, 39 Victoria-street, S.W.	20	Dowson ..	National ..	190	18	10	20	20	200	10·00	10·00	
12	The Campbell Gas Engine Company, Limited, Halifax	18	Campbell..	Campbell..	200	19	9½	18	17	180	10·00	10·59	Variable timing gear. Renewable seats to valves
13	The Campbell Gas Engine Company, Limited, Halifax	20	Campbell..	Campbell..	190	20	10	20	18	225	11·25	12·50	Throttle governor. Renewable seats to valves. Variable timing gear
16	The Dudbridge Ironworks, Limited, Stroud, Gloucestershire	20	Dudbridge.	Dudbridge.	200	17	9½	20	20	1 3	9·65	9·65	
17	The Mersey Engine Works Company, Sefton-street, Liverpool	20	Mersey ..	Gardner ..	200	18	9	20	20	176·5	8·82	8·82	
19	E. S. Hindley and Sons, Bourton, Dorset	20	Hindley ..	Hindley .	600	7	7	16	—	280	17·50	—	Vertical engine. Two cylinders. Variable timing gear
20	Kynoch, Limited, Holford Engine Works, near Birmingham	17	Kynoch ..	Kynoch ..	240	18	9	17	17	198	11·65	11·65	Petrol self-starter
21	Newton Bros., Market Place, Derby	20	Newton ..	Newton .	200	18	9	20	—	210	10·50	—	Vertical engine
28	Fielding and Platt, Limited, Gloucester	20	Fielding .	Fielding ..	220	18	9½	18	18	200	11·10	11·10	
30	Crossley Bros., Limited, Openshaw.	17	Crossley ..	Crossley ..	200	21	8½	17	—	209	11·77	—	Exhaust regenerative type of producer
31	Crossley Bros., Limited, Openshaw.	15	Crossley ..	Crossley ..	180	21	8½	15	13	180	12·00	13·85	

Except as otherwise stated the engines were single-cylinder single-acting 4-cycle (Beau de Rochas, generally known as "Otto" cycle) horizontal type, and were governed on the "hit-and-miss" principle.

TABLE XIII.—*Gauge Pressures Measured from Ordinary Indicator Diagrams and from Mathot Diagrams (Full Load only).*

Number in catalogue.	Name of plant.	Maximum initial pressure, lb. per sq. in. Anthracite full load. Varied from	to	Coke full load. Varied from	to	Compression pressure, lb. per sq. in. Anthracite full load. Working stroke.	Idle stroke.	Coke full load. Working stroke.	Idle stroke.	Vacuum at beginning of compression stroke, lb. per sq. in. Anthracite full load. Gas and air valves open.	Air valve alone open.	Coke full load. Gas and air valves open.	Air valve alone open.
7	National	240	300	260	340	160	150	155	140	0·2	0·5	0·5	1·5
8	Railway and General .	220	380	190	340	120	95	—	90	0·9	4·5	—	—
9	Davey-Paxman	200	310	150	230	115	85	110	75	1·2	—	—	—
11	Dowson	300	300	250	3 0	140	130	—	120	0·3	0·5	0·5	—
12	Campbell	340	420	360	420	155	140	150	130	1·0	3·0	1·2	2·0
13	Campbell (Throttle) ..	180	370	150	150	150	—	155	—	1·5	—	2·3	—
16	Dudbridge	280	320	—	—	110	85	—	—	2·0	4·0	—	—
17	Mersey	400 after every 300	360	"miss" 170	270	120	110	—	90	0·5	—	—	—
*19	Hindley	200	270	—	—	—	—	—	—	—	—	—	—
20	Kynoch	240	300	190	345	145	130	—	120	1·8	—	—	—
21	Newton	260	400	—	—	200	200	—	—	0·4	0·6	—	—
28	Fielding	210	300	150	255	115	85	—	75	1·2	4·3	—	—
30	Crossley	Not indicated			—	—	—	—	—	—	—	—	—
31	Crossley	435	510	360	490	210	190	195	165	0·5	—	0·5	3·5

* Mathot diagram only.

constituents—in the case of anthracite—are gradually given off. None of the producers on trial was provided with an automatic stoking device for delivering the fuel in small measured quantities into the furnace from the hopper.

Although the producers are alike in general design, there is considerable diversity in the designs of the vaporiser. As already mentioned, the vaporiser is sometimes external, sometimes wholly internal, and sometimes partly external and partly internal. In some cases it takes the form of an open-mouthed boiler, made either of cast iron or of steel; sometimes a coiled pipe is used; or, again, the vaporiser is merely a heated surface over which the water trickles. Examples of all these forms of vaporisers were present in the producers at the Derby trials.

A detail of importance in connection with the vaporiser is the means adopted for regulating the water supply so that it may be sufficient at all times and varied as required by the load; at light loads the supply must be reduced in order to maintain the temperature in the furnace. In many producers the regulation is done by hand by means of a cock or valve, but in others the action is automatic. There are three methods of automatically regulating the water supply:—

(1) By adjusting the amount of water sucked in.

(2) By adjusting the amount of a secondary—dry—air supply, thus reducing the proportion of water vapour introduced into the furnace.

(3) By varying the temperature of the air supply, which quickly changes its water vapour carrying capacity.

One of the reasons for the desirability of regulating the supply of steam is that if the engine is put to work on a low load after a heavy load, without reducing the amount of steam, a very rich gas will be produced, and there will be so many cut-outs that the fire may go dead. The "Mathot" indicator cards well illustrate this point; but the regulation of the water supply—which in this case was automatic—very soon reduced the steam supply and lowered the explosion pressure.

The air supply can be preheated before being brought into contact with the water, and this treatment of the air supply was one of the points of greatest divergence in the various producers submitted for trial. In some of them the air was more or less carefully heated by means of the hot gases, &c., before being brought into contact with the vaporising water; in others, however, the air was not preheated at all. If the best advantage is to be taken of the air as a heat carrier, with a view to apply the regenerative principle, the air should be saturated whilst being heated by the gas coming out of the producer. An examination will show that the following producers, amongst others, take more or less advantage of this fact:—The National, Newton, Dowson, Dudbridge, Fielding, Campbell, Kynoch, Crossley, Mersey, Hindley. It is thought, however, that improvement is still possible in this direction.

The scrubber was practically the same in all the producers, and consisted of a cylindrical vessel partially filled with coke, over and through which the water trickled. The water supply was effected by means of a rose or a circular pipe with holes. In the case of the Crossley producer there was a layer of sawdust on the top of the broken coke.

The producers are started by means of hand fans. These fans were of various makes, and some of them were much easier to turn than others. This is an important detail, and ease of working will appeal to the attendant. The fans produced a pressure in the producer, and there is an advantage in this, because any leaks in the producer are at once detected by the smoke coming out. These leaks would let air in when under suction, and the efficiency would be much reduced.

As it was not possible to publish indicator and Mathot diagrams of all the engines, an abstract has been made—see Table XIII.—giving the important pressures recorded on these diagrams, namely, the "maximum initial pressure," "the compression pressure," and the "vacuum at the beginning of the compression stroke." There is a considerable variation in the maximum initial pressure from stroke to stroke; accordingly the limits of this variation are given in Table XIII., and it will be seen that in most cases this variation exceeds 50 per cent., reckoned on the lower pressure.

The compression pressure is greater for the working stroke than it is for the idle stroke, the difference being due to the throttling action of the air valve, an action which is further exhibited by the figures given for the vacuum at the beginning of the compression stroke. These figures are expressed in lb. per square inch, and are measured below the atmospheric line. The vacuum, when the air valve alone is opened—that is, for an idle stroke—is of no special importance, the extra work thrown on the engine being very small. In the case of the working stroke, however, the smaller the figure ths better, as it means a considerable increase in the weight of the charge taken in. These measurements were made from weak spring diagrams, and such diagrams were not taken for all the engines, hence the blanks.

SOCIETY OF MOTOR OMNIBUS ENGINEERS.

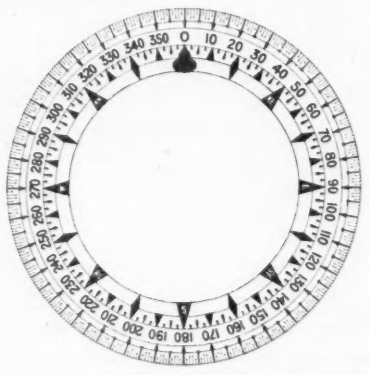
A PAPER on "Some Commercial Aspects of Motor Omnibuses" was read before the above Society on Monday last by Mr. A. A. Campbell-Swinton, M. Inst. C.E. The author estimates that these vehicles are now carrying at the rate of 184 millions of passengers per annum, or some thirty times the entire population of the metropolis, yearly. Furthermore, if the moderate amount of only £4 be taken as the daily gross earnings of a motor omnibus, upon the same figures it is found that the motor omnibuses of London are at present taking very nearly £1,000,000 sterling per annum, the greater part of which is again distributed as wages to the large number of drivers, conductors, cleaners and workmen that are employed.

An interesting comparison is made respecting capital expenditure on the motor omnibuses and on the County Council tramways. Mr. Swinton says:—"If a sum of £1,000,000 be taken as the cost of the whole of the motor omnibuses now running on the London streets, together with their garages, workshops, and other appurtenances, we shall be allowing a very full amount. On the other hand, Mr. McKinnon Wood, on the same occasion that he gave 180 millions as the number of passengers carried by the London County Council tramways last year, stated that the expenditure upon the Council's tramways to date had been about five millions, and that they intended to spend five millions more. Thus, we have the remarkable result that the County Council have spent five millions of public money on tramways, and are with these tramways carrying only 180 million passengers per year, while the companies running motor omnibuses, with an expenditure of less than one-fifth of that amount, are carrying 184 millions, or four millions more than the tramways. Of course, capital expenditure is not everything, though, in these days of dear money, it is a matter of great importance, but it is, undoubtedly, of interest to note that, while the London County Council tramways, with five millions of capital, carry 180 million passengers yearly, or 56 passengers yearly per £1 of capital; that, while the London United Tramways, with about three millions of capital, in 1904 carried 48 million passengers, or only about 16 passengers per £1 of capital, and that, while the Central London Railway, with nearly four millions of capital, carried in 1905 45 million passengers, or only a little over 11 passengers per £1 of capital, at the same time the London omnibus companies, with about one million capital, spent on motors and their appurtenances, are carrying 184 millions of passengers, or 184 passengers yearly for each £1 of capital spent. On the subject of noise and vibration, Mr. Swinton attributes nine-tenths of these nuisances to the bad condition of the road surfaces, and he also considers that the real causes of side-slip are the unsuitable nature of the surfaces of our streets to the traffic that they have to carry, the extent to which these surfaces are allowed to become covered with grease, and to the quite unnecessary and useless amount of camber that is usually given. The paper also dealt with such subjects as the liability of local authorities for maintaining the road surfaces in a safe condition, the police tests for noise, the dropping of grease on the roads, and economy of operation. An interesting discussion followed.

A MARINER'S COMPASS CARD.

A NEW compass card has been designed by Mr. F. Howard Collins, which he claims meets the requirements of modern navigation better than those now in use. He further claims that the readings are more briefly expressed, more exact, and that there is less liability to make a mistake. The card, which is supplied by Messrs. Kelvin and White, of Cambridge-street, Glasgow, is made in a standard size of 10in. diameter. The method of marking off is shown in the illustration. Each degree from 0 to 360 is given, and the divisions. N.E., E., S.E., S., S.W., W., N.W., N., are all marked upon the card. Simplification of readings is probably its chief feature. For instance, the direction of N. 57 deg. E. becomes simply 57 deg., the letters in all cases being omitted. When the compass is boxed and the number of letters so used are counted, they amount to 76, together with 16 "by's," making a total of 92. The number of figures used to express these same bearings to the nearest whole degree is 64. So the figures are fewer than the letters in the proportion of 7 to 10.

Among the advantages claimed may be mentioned the method for allowing for "deviation." These allowances are



reckoned readily, because all easterly deviation is additive to the compass course in order to get magnetic bearings, and all westerly deviation deductive. With ordinary cards the deviation allowances in some quadrants have to be added and in others subtracted. There is no conversion of points into degrees or *vice versâ*. All compass work is recorded in degrees only. The variation being westerly, it is always subtracted from a compass course that is given in degrees in order to get the magnetic bearing. For determining azimuths the following easy rule does away with the necessity for sundry tables. Whatever the declination:—In north latitude a.m. time, the azimuth is the degree shown; in north latitude p.m. time, deduct the degrees shown from 360. In south latitute a.m. time, deduct the degrees shown from 180; in south latitude p.m. time, add the degrees to 180.

THE National Telephone Company opened eight new exchanges during November, making a total of 1269. 4001 new stations were added during October, making a total of 399,389.

SCOTTISH INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—At the usual monthly meeting of the Institution of Engineers and Shipbuilders in Scotland, held in the Institution Rooms, Bath-street, Glasgow, on the 18th inst., Mr. James Gilchrist presiding, discussion took place on papers by Mr. E. M. Speakman on "The Development and Present Status of the Steam Turbine in Land and Marine Work," read at the meeting before last, and on "Gas Engines and Suction Gas Plants," by Mr. Hugh Campbell, read at last meeting.

TESTING WOODEN POLES.—Additional tests as to the breaking stress and deflection of telegraph and telephone poles, both single and double, were held at R. Wade, Sons and Co., Limited, yard in Hull on 11th and 12th December, supplementing those made in August last. These were carried out by Professor Goodman, of the Leeds University, assisted by Messrs. Greener and Boyd Carpenter. The arrangements were made by Mr. Christopher Wade, and, although the weather was most unfavourable, were attended by a number of people interested in the strength of wooden poles both for power and other overhead work, including representatives of several railway companies, electric power companies, and contractors. The tests were considered very satisfactory, and in consequence, Messrs. Wade having got all the data they require, they will at once be compiled in a clear form for the use of electrical engineers and contractors.

ROYAL METEOROLOGICAL SOCIETY.—The monthly meeting of this Society was held on Wednesday evening, the 19th inst., at the Institution of Civil Engineers, Great George-street, Westminster, Mr. Richard Bentley, F.S.A., president, in the chair. Admiral J. P. Maclear read a paper on "The Guildford Storm of August 2nd, 1906." This storm showed some very curious and interesting features, in the remarkable violence of the wind, rain, and hail, within a small area, and the suddenness with which it burst. There was an area of thunderstorms over the whole of the South of England on the evening of that day. The most violent storm, however, burst over Grayshott on Hindhead at 8 20, and pursued a narrow track through Godalming and Guildford to Ripley, five miles north-east of Guildford. The wind was of hurricane force, and blew down an immense number of trees and caused other damage, and also the loss of two lives. The rain, accompanied by large hailstones, was very heavy, as much as 1·17in. falling at Grayshott in fifteen minutes. There was a magnificent display of lightning, the flashes being incessant, and darting from cloud to cloud. Mr. R. Inwards read a paper on "The Metric System in Meteorology." The author did not discuss the general question of the advantages of the metric system over that in use by Britain and her Colonies and the United States of America, but confined his remarks to the advisability of adopting some uniform system by all the meteorological observers upon the globe.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Pig Iron Rush Stopped.

IT would hardly be fair to speak of the Birmingham market to-day—Thursday—as less strong, but it would be quite correct to describe the position as less exciting. The decline in the Scotch and Cleveland warrant markets has had a sobering effect, and the upward rush in pig iron, for the moment at any rate, is over. Still, there was no retrogression locally, and last week's rates had to be paid if business was meant.

Makers' Manufactured Iron Unaffected.

The sheet iron trade continues very active, and neither in this branch nor in bar iron were makers' prices materially affected by weaker pigs. Galvanisers are still remarkably busy, and are making urgent demands upon the rolling mills for deliveries. South Staffordshire black sheets are firm at £9 to £9 2s. 6d., and in some cases £9 5s. per ton for w.g. materiel; £8 17s. 6d. to £9 for 20 w.g.; and £9 12s. 6d. to £9 15s. for 27 and 28 w.g. material.

Merchant Underselling.

There has been some underselling in the galvanised sheet branch, traceable, it is said, to merchants who bought heavily before the present high level of prices had been reached. Some merchant business has been done below the Association minimum of £13 5s. But this has not materially disorganised the market, as is clear from the fact that leading makers adhere to their last week's quotation of £13 15s., and state that they are able to command this premium of 10s on the official basis. A few makers are even quoting as much as £14. There is more activity in regard to spelter, galvanisers showing more anxiety to cover rather short. Virgin changes hand at £28 12s. 6d., and hard at £23 15s., delivered Birmingham.

Bar and Hoop Iron Prices.

Staffordshire marked bars on Birmingham Exchange this afternoon maintained the new standard of £9 per ton, and makers reported that inquiries were arriving freely, and that the recently imposed 10s. advance had not acted deleteriously. A brisk trade was again effected in unmarked bars. Merchant qualities were for the present sustained at £7 10s., though minimum quantities might have been bought at £7 5s. or less. Hoops were £8 10s., and slit nail rods maintained last week's advance of 10s., the new quotation for these also being £8 10s. per ton. An enormous volume of business is represented by the inquiries for export for galvanised sheets, deliveries not to begin before March, but it must not be assumed that all these inquiries have yet crystallised into actual orders.

Steel.

Steel was scarce, and it is only by maintaining a high level of prices that makers can prevent inconvenient booking. All the makers hold heavy contracts. Bessemer billets were £6 5s. to £6 10s., some sellers of Siemens asked as much as £6 10s. to £6 12s 6d., and as a nominal figure even £6 15s. per ton.

Advance in Roll Prices.

Owing to the advance in best all-mine Staffordshire pig iron prices, which is made concurrently with the recent advance in Staffordshire marked bars, chilled iron and steelworks rolls have been officially advanced by the makers £1 per ton, and grooved and grain rolls 10s. per ton. It is not unlikely that other advances in heavy ironfounding and engineering work will follow.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, December 19th.

Pig Iron Still Excited.

ON Tuesday, on the Manchester Iron 'Change, owing to the sudden drop in warrants in the course of the afternoon, the market virtually went "all to pieces." No reliable quotations were obtainable. There was scarcely an ounce of Scotch iron in stock at the Manchester docks—a state of things which it may be safe to say has never happened since they were opened. The little arriving is eagerly appropriated. As a result of the excitement regarding warrants, prices toned down a little, and we could not hear of any large amount of business being put through. Lincolnshire, Derbyshire and Staffordshire iron maintained full rates, but sales were subject generally to makers' time of delivery. There was next to nothing doing in forge iron.

Finished Iron.

One or two makers on 'Change assured us that recent advances were readily paid by buyers. They were well booked for the early part of next year.

Steel.

Steel and steel products still rule firm, and section is the turn dearer. The advance in plates is well maintained.

Copper.

Manufactured, following the course of the raw metal, was again dearer. Sheets advanced £3 per ton, but tubes remained unchanged. Ingot copper was about £2 per ton higher.

Quotations.

Pig iron: Lancashire No. 3 foundry, 64s.; Lincolnshire, 65s. 6d. to 66s. 6d.; Staffordshire, 66s.; Derbyshire, 67s. to 68s.; Middlesbrough, open brands, 71s. 10d. to 72s. 4d. Scotch: Gartsherrie, 78s. 6d.; Glengarnock, 77s.; Eglinton, 75s.; Dalmellington, 75s., delivered Manchester. West Coast hematite, 82s.; East Coast ditto, 81s., f.o.t. both Scotch, delivered Heysham: Gartsherrie, 76s. 6d.; Glengarnock. 75s.; Eglinton, 73s.; Dalmellington. 73s. Delivered Preston: Gartsherrie, 77s. 6d; Eglinton, 74s.; Glengarnock, 76s.; Dalmellington, 74s. Finished iron: Bars. £7 15s.; hoops, £8 7s. 6d.; sheets, £8 12s. 6d. to £8 17s. 6d. Steel: Bars. £7 10s. to £7 15s.; hoops, £7 17s. 6d. to £8; boiler plates, official, £9 2s. 6d.; plates for tank, girder, and bridge work, £7 10s. to £7 15s.: English billets, £6 12s. 6d. to £6 17s 6d.; sheets, £8 17s. 6d. Copper: Sheets, £123 to £125; tough ingot copper, £112 10s.; best selected, £112 to £114 10s. per ton; seamless copper tubes, 14d. to 14½d.; brazed ditto, 14½d.; seamless brass tubes, 11½d.; brazed ditto, 12d.; condenser, 12d. to 12½d.; brass wire, 10½d.; rolled brass, 10d. to 10½d.; brass screwing rods, 10d. to 10½d. per lb. Sheet lead steady at £22 5s. per ton. Tin: English ingots, £196 to £197 per ton.

The Lancashire Coal Trade.

The Coal Exchange on Tuesday was well attended, as this is practically the only market before the New Year. As the colliers will then have an advance of 5 per cent. on their wages, there was some anxiety to cover forward requirements in some departments. For slack and on shipping account there was an upward tendency in prices, but generally late quotations are repeated.

Labour in the Engineering Trades.

We continue to receive favourable reports of the condition of things in Lancashire. Much overtime is being worked in the textile machinery shops, and one authority states that deliveries

are very behindhand, and that from 30 to 40 per cent. more money is being asked by machine makers. This, however, must be taken with the proverbial grain of salt. Machine tool makers are very busy, and the prospects for some time into next year are exceedingly good.

BARROW-IN-FURNESS, December 20th.

Hematites.

The demand for hematite pig iron is thoroughly well maintained, and the market is not only strong, but there are increasing evidences that the improved trade now being done will continue for a considerable time yet. Prices of mixed Bessemer numbers are at 81s. per ton net f.o.b., but some makers are quoting 83s., while others are too well sold to quote at all. There would soon be an increased production of iron, but the maximum of blowing power is now being utilised, or nearly so, and there would be serious difficulty in finding ore for more than two or three additional furnaces. Warrant sellers are at 79s. 6d. net cash, buyers 1d. less. Stocks have been increased by 1000 tons. They stood on Monday at 71,955, and are now at 72,955, but as these stocks are held to a large extent by users to cover future requirements, they are not looked upon as a speculative element in the market. There are thirty-eight furnaces in blast, and there is a very heavy yield of metal. Iron ore is in brisk demand at about 18s. a ton net at mines for good average sorts.

Steel.

The steel trade is better employed, but makers are not well off for orders, and this is especially the fact as regards rails, the demand for which is very quiet, and prices are such as prevent would-be buyers from placing their orders at the moment. Heavy sections are at £6 10s. to £6 12s. 6d. per ton net f.o.b. In shipbuilding material the business doing is very moderate, and orders are not coming in well, but there is a much better prospect of new business in the early future, not only on local but on general account. Prices are firmer at £7 12s. 6d to £7 15s. per ton net cash. The rail mills are still being used for the production of billets and tie bars, for which there is a fair demand. Merchant steel is very quiet, and orders are coming in slowly.

Shipbuilding and Engineering.

The shipbuilding trade is quiet, but orders are expected shortly as well for Admiralty work as mercantile tonnage. In the meantime there is nothing on the stocks at Barrow but a Brazilian battleship, whose construction has been suspended for alterations in design. During 1906, at the Barrow shipyard, 26 770 tons of shipping was launched and engines of 79,000 horse-power were built.

Shipping and Coal.

The shipping trade is moderately employed. The shipments to date this year have reached a total of 789,153 tons, being a decrease on the same period last year of 4146 tons. Coal and coke are in fuller demand, and the recent advances in price are fully maintained.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

General.

THE work of the year in the lighter staple industries will practically end this week. Christmas holidays will run, in the majority of the establishments devoted to cutlery, silver, plating, and allied industries, right into the New Year. The offices will receive the usual attention for correspondence and similar duties, but the workshops will generally be closed. The heavy industries, on the other hand, will not admit of such prolonged holiday. In most instances there will be a week's cessation, with the exception of one or two departments. The holidays are usually utilised for stocktaking, and making needful repairs and alterations, although a number of the manufacturers, both in the light and the heavy trades, prefer to take midsummer for these purposes. The miners, as a rule, are given to making much of Christmas season for "play."

House Coal.

A short spell of winterly weather at the end of last week stimulated the call for household fuel, and the approach of the holiday season has sustained the activity. A greater demand is reported for the better grades of coal, for London and the South, as well as on local account. To the Eastern Counties there have been fully average consignments of good secondary descriptions. The metropolitan consumers prefer the best qualities of Silkstone, which fetch up to 12s. 6d. per ton, secondary sorts realising from 10s. to 10s. 6d. per ton. In Barnsley thick house seam, the output is in excess of market requirements, but anything like a continuity, even for a brief season, of hard weather, would soon alter that condition of affairs. Prices for this class of coal range from 10s. 6d. in the best samples to 8s. 6d. and 9s per ton at the pits. In addition to the weight consigned South and East by rail, a heavy tonnage is sent to Hull, for the coastwise trade, for which London is by far the largest customer. Complaint is freely heard, on the part of colliery owners and merchants, of the shortage of wagons causing delay on the railways This traffic delay is stated to be affecting the gas companies in some inland districts, where difficulty is reported to be experienced in obtaining supplies on contract account adequate to meet their immediate requirements.

Railway Coal Contracts.

All indications point to a settlement being made on the basis of 9s. 6d. per ton—the rate fixed in the original tenders sent in by the South Yorkshire coalowners. The railway companies, it will be remembered, offered to give 6d. per ton more than the price they are paying under the expiring contracts. The coalowners, however, kept stiffly to their first figure, and their position has now been made stronger by the North-Eastern Railway Company having agreed to pay 9s. 6d per ton for its supplies of South Yorkshire hard coal for the year ending December 31st, 1907. The other companies now seeking locomotive fuel from South Yorkshire coalowners are expected to fall into line, but up to the time of writing we have not heard of definite arrangements to that effect. The Midland Company, however, is stated to have agreed with Derbyshire colliery proprietors for top brands at 8s. 6d. per ton, which is an advance of quite 9d. per ton over the prices arranged a year ago. In the general steam coal trade the business done is extremely satisfactory, full values being realised. Except on contracts that are running, 9s. per ton is the minimum price ruling, the rate ranging from that figure to 9s. 3d. and 9s. 6d. per ton, with a firm market. There is also an excellent trade doing in steam nuts at 7s. 6d. and 8s. per ton.

Coking Slack, Smudge, and Coke.

Coking slack and smudge, in the best qualities, is in active request, the consumption by the patent ovens being at present exceptionally large. Prices are somewhat higher, ranging from 4s. 9d. to 5s. per ton for the better descriptions. Manufacturing fuel continues to be consigned, in heavy tonnage, to the Lancashire cotton and Yorkshire woollen districts, the pit prices being from 3s. 6d. to 3s. 9d. per ton. Contracts over next year are being made at considerable advances on the expiring rates. The activity already reported in coke is more than maintained. Large as the output is now, the market is more than sufficient to absorb it, and the district makers have their production well booked. Rates are stiffening, and should the existing "boom" in the iron trade be continued, higher prices are certain to obtain. The dearness of Durham coke, and its scarcity, have caused local makers to be firmer, more especially in respect of North Lincolnshire and Derbyshire. The quotations given last week are maintained, with prospects of further advances early next year.

Iron and Steel.

The Lincolnshire Ironmasters' Association, up to the time of writing, has made no advance on the official quotations given last week, which remains at 62s. 6d. per ton for No. 3 foundry, 60s. 6d. per ton for No. 4 foundry, 59s. 6d. per ton for No. 4 forge, and 63s. per ton for No. 5 forge, mottled, white, and basic. A similar report has to be given respecting Derbyshire iron, which maintains the advances noted last week—No. 3 foundry making 64s. per ton, and No. 4 forge 59s. per ton. Both in Lincolnshire and Derbyshire makers are not anxious about business, all the producers being sold ahead for some months, and there being practically no iron on offer. It is quite a common occurrence for offers at the advanced prices to be refused. Bars remain at £7 15s. to £8 per ton; sheets, £9 5s. to £9 15s. per ton. The upward tendency in hematites has still to be noted. There is no buying beyond pressing requirements; but where supplies are called for 90s. to 91s. per ton has to be paid for West Coast hematites, less 2½ per cent. delivered at Sheffield and Rotherham, and 86s. to 87s. per ton for East Coast, net. These figures denote a rise of 1s. per ton in each instance on the week. All the leading steel establishments are full of work, with every prospect of brisk business being maintained in the New Year.

Railway Materials, &c.

This important department of the heavy industries is fully employed, largely on account of distant markets, although several fair lines continue to come in for British railways. One branch, the manufacture of railway wagons, is certain to be busier in the New Year, as the shortage of wagons is being keenly felt, especially in colliery districts. A fair amount of work is now in hand, but much more could be done. In tires, axles, wheels, springs, buffers, and similar material, the manufacturers are generally busy, with every probability of being more actively engaged in the opening months of next year. Local boilermakers and repairers are actively engaged, and overtime is being worked in the majority of instances. At the local foundries the principal work is stated to be for colliery specialities, but no extreme pressure is reported in the different establishments.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Trade Situation.

THE market for all kinds of iron and steel is substantially improving, and all indications are in favour of its continuing to do so, both in the matter of demand and prices. Both are more satisfactory than they have been at any time since the autumn of 1900, and in nearly all cases manufacturers are already well supplied with orders for execution during the first half of next year. Exports are still very brisk, and stocks of pig iron decline. The reports, which are well founded, of a spurt in the shipbuilding industry have had a good influence on trade generally, for during the autumn the weak point of the situation in this district has been the absence of new orders for steamers; now there is no hesitation about their distribution, and, what is more, there is a more satisfactory outlook for shipping. The change for the better is manifest also in the plenitude of orders lately secured by the producers of shipbuilding material, and we have steel plates which never moved in price between October, 1905, and the present month, being advanced 10s. in about a fortnight in two instalments of 5s. each, and angles have gone up to the same extent. This improvement in the finished branches of the iron and steel industries has restored confidence, so that the "slump" in the prices of Cleveland warrants and makers' iron has really had very little adverse influence upon the market, it being so obviously the outcome, not of legitimate trading, but of the operations of speculators. Cleveland pig iron is the only thing that has become easier in price this week.

Cleveland Warrants.

Influences have been rather unfavourable to the speculative market this week, and operators being more eager to sell than to buy, there has been a substantial drop in prices, which, however, it is believed, will be recovered after the holidays. The adverse influences have been the heavy sales by the speculators, who are on the hunt for profits, a position which comes at intervals in every upward movement. The increasing dearness of money shown by the advances in the bank rates, both at home and abroad, makes it more expensive to carry warrants, and many holders want to get out before the holidays. It is considered by the shrewdest and most cautious traders that the highest price that is likely to be touched by Cleveland warrants for some weeks has already been reported this month, and that a "set back" will rather do good than otherwise, as prices have during the last few weeks been going up too fast; as much as 63s. 4d. cash buyers has been reached, but this week sales have been reported at 60s. 8d., the drop being even more rapid than the advance was. But it is well recognised that the condition and prospects of trade have nothing to do with this "slump"—it is due to pure speculation—but it hampers legitimate business.

Cleveland Pig Iron.

Makers' iron has this week been offered at prices below those reported last week, but it was by second hands. The makers themselves generally refuse to quote, as they are well off for orders for execution over the first half of 1907; indeed, there are some who cannot sell any iron for delivery before August. Very good contracts have been booked this month, especially on export account, and it seems pretty certain that the next half year will be as remarkable for its heavy shipment of pig iron as the current half year has been. The prices of Cleveland pig iron have been practically nominal this week; Tuesday's rates were:—No. 3 at 61s. 6d.; No. 4 foundry at 60s. 6d.; and No. 4 forge at 59s. 6d. But there was a recovery on Wednesday, No. 3 being quoted at 62s.

Hematite Pig Iron.

Speculation has little influence in this branch, for there is no stock either in makers' hands or the public warrant stores, with which speculators can operate, and fluctuations in prices are governed practically by legitimate trade. For East Coast hematite iron they have been rising, while for Cleveland iron they are declining. A further 1s. 6d. per ton has been added to the quotations for mixed numbers hematite this week, making them 81s. 6d. per ton, whereas a fortnight ago they could have been bought at 76s., a month ago at 70s., and they have been as low as 65s. per ton this year. The advance has been rapid, but it has been brought about by improvement in legitimate trade. Rubio ore has risen to 23s. 6d. per ton c.i.f. Middlesbrough, and it is difficult to get supplies, as the Germans have bought heavily from the Spanish mineowners. Larger imports will during the next few months be made from the South of Spain, an unprecedented number of steamers having lately been chartered.

Cleveland Ironstone.

The quantity of ironstone now being got from the Cleveland mines does not satisfy the requirements of the ironmasters, although the output is the largest that has been reported since the year 1883, and considerable attention is directed to the efforts that are being made to discover further supplies in the southern part of Cleveland. Mr. J. J. Burton, of Middlesbrough, is opening out a seam of ironstone on the west side of Roseberry Topping, and this will be won partly by a drift and partly by open workings. Some of the Cleveland ironmasters are importing ironstone from Northamptonshire and Leicestershire for mixing with their own stone in the manufacture of Cleveland ordinary iron. This must cost them 8s. or 9s. per ton, delivered at their furnaces, against 6s. for Cleveland stone.

Manufactured Iron and Steel.

For some months there has been a lull in the distribution of fresh orders for manufactured iron and steel. The producers had plenty of old orders, however, and have in nearly all cases kept their establishments in full employment. There has sprung up a most satisfactory change for the better, and advantage is being taken of it to advance prices. The plate and angle manufacturers have raised their quotations another 5s. per ton this week, making 10s. rise in about a fortnight. Plates were absolutely stationary in price from October 1905 to the present month. No surprise is expressed about this second advance so soon after the first, because consumers expected that the first would have been 10s. The increase is justified not only by the larger demand, but also by the increase in the cost of pig iron and fuel. Steel shipplates are now at £7 10s.; steel ship angles, at £7 2s. 6d.; steel bars, at £7 10s.; and iron bars, at £7 15s., all less 2½ per cent., f.o.t.

Shipbuilding and Engineering.

A marked improvement in business is reported in connection with the shipbuilding industry of this district. Shipowners are securing fuller employment for their vessels, as well as better freights in certain trades, and as it is apparent that they are not likely to see lower prices for new steamers, they are giving out orders rather freely. The operations at the Teesside and Hartlepool shipyards are hampered through the strike of the platers, which has been going on for over six weeks, and plating work is practically at a standstill. On Monday last there was a sixth conference between the employers and the representatives of the men, but the differences were not adjusted, though the proceedings lasted about eleven hours—this after a sitting of over nine hours on Wednesday of last week. A seventh conference is to take place to-day—Friday—at Stockton.

Coal and Coke.

In all respects the coal market is satisfactory, and colliery proprietors never knew a larger demand. The prospects for next year are encouraging, especially in regard to exports, and the exports would be even larger than they are if adequate facilities existed in Germany and Italy for conveying the fuel inland from the ports. Best steam coal is at 12s per ton f.o.b., and seconds at 11s. Best gas coals have risen to 11s. 3d. per ton. The most improvement is noticeable in the coke trade. Our manufacturers cannot supply enough, and have been able to advance their prices rather rapidly. In July they were selling médium coke at 16s. 4½d. per ton delivered at the Middlesbrough furnaces, and less than a month ago coke was obtainable at 19s., but now consumers have to pay 22s. 6d. per ton for it for delivery over the first half of next year, and 25s. to 26s. has been quoted for delivery during the forthcoming holidays.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

Reaction in the Warrant Market.

A SUDDEN fall in prices in America, which was reported here at the beginning of the present week, led to considerable excitement in the pig iron market. The fall was so totally unexpected that holders of warrants showed considerable anxiety to sell. A large amount of iron was thrown back upon the market, and Cleveland warrants declined from 62s. 6d. to 60s. 8d. cash. Business was also done in these warrants from 62s. 6d to 61s. one month. Cumberland hematite fell from 81s. 4d. to 79s. 6d. cash. Scotch warrants are now quoted nominally 67s. and standard foundry pig iron 60s. per ton.

The American Demand for Iron.

The demand for Scotch pig iron for shipment to the United States continued up till the end of last week. Scotch makers are now so fully supplied with orders that they can afford to wait for some time on new business, so that the break in prices in America will not materially affect them. It is reported that the Americans are still inquiring anxiously for hematite pig iron for delivery well into next year. Scotch hematite has been very strong, and prices have touched 82s. 6d. per ton for delivery at the West of Scotland steel works.

Prices of Scotch Makers' Iron.

The prices of Scotch makers' iron have all advanced since last report, in amounts varying from 1s. to 2s. 6d. per ton. G.M.B., No. 1, is quoted at Glasgow 72s.; No. 3, 70s.; Govan and Monkland, Nos. 1, 73s. 6d; Nos. 3, 70s.; Carnbroe, No. 1, 75s.; No. 3, 71s.; Clyde, No. 1, 77s.; No. 3, 72s.; Gartsherrie and Calder, Nos. 1, 77s. 6d.; Nos. 3, 72s. 6d.; Langloan, No. 1, 79s.; No. 3, 74s.; Summerlee, No. 1, 81s.; No. 3, 73s. 6d.; Coltness, No. 1, 86s.; No. 3, 73s. 6d.; Glengarnock, at Ardrossan, No. 1, 77s.; No. 3, 72s.; Eglinton, at Ardrossan or Troon, No. 1 73s.; No. 3, 70s.; Dalmellington, at Ayr, No. 1, 75s.; No. 3, 70s.; Shotts, at Leith, No. 1, 77s. 6d.; No. 3, 72s. 6d.; Carron, at Grangemouth, No. 1, 77s.; No. 3, 72s. per ton.

Output and Stocks of Iron.

Since last report an additional hematite furnace has been lighted at Wishaw, and there are now 40 furnaces producing hematite, 44 ordinary, and 6 basic iron, the total of 90 furnaces thus in operation in Scotland comparing with 91 at this time last year. The stock of pig iron in Glasgow warrant stores has been reduced to some extent since last week. The stores now contain a total of 9611 tons, of which 5611 is ordinary, and 4000 tons standard foundry pig iron.

Shipments of Pig Iron.

The shipments of pig iron from Scotch ports in the past week amounted to 10,727 tons, compared with 5835 in the corresponding week of last year. There was despatched to the United States 4925 tons; Canada, 375; South America, 300; India, 105; Australia, 405; France, 145; Germany, 35; Holland, 235; Belgium, 80; Spain and Portugal, 27; China and Japan, 260; other countries, 644; the coastwise shipments being 3091 tons against 3305 in the same week of 1905. The arrivals of Cleveland iron at Grangemouth amounted to 7307 tons, against 12,198 in the same week of last year, showing a decrease of 4891 tons. There is, however, a total increase in these imports since the beginning of the year amounting to 16,641 tons.

The Ore Trade.

The prices of hematite ore are at present very high, and there is also some anxiety with reference to future supplies to meet the increasing demand of the steel makers. Attention is being called to various districts from which ore might be obtained. It is reported that considerable quantities of good ore, comparatively free from sulphur and phosphorus, are likely to be obtainable from Australia, and that a cargo of 1800 tons of this ore is now on its way to Glasgow.

Finished Iron and Steel.

The makers of finished iron and steel are now very well supplied with orders, not only up to the end of the year, but they

have in hand work which will enable them to make a good start after the holidays. In some cases, indeed, the contracts entered into are for delivery over a considerable period of next year. A further advance has been made in the prices of steel, and as a corresponding increase has taken place in England, it is expected that values for future business will be maintained, unless there should be some further decided reaction in the market.

New Contracts.

The contract for widening Blackfriars Bridge, London, has been secured by Sir William Arrol and Co., of Glasgow, the price being stated as upwards of £200,000. It will be remembered that the same firm carried out the contract for the erection of the Tower Bridge. A number of other contracts are reported, these involving a considerable amount of structural work.

The Coal Trade.

There has been a quieter feeling in the coal trade. The past week's shipments from Scotch ports amounted to 210,447 tons, being 23,585 tons less than in the preceding week, and 26,268 below the quantity despatched in the corresponding week of last year. There is still, however, an aggregate increase in these exports for the year to date of 1,370,000 tons. A few days ago some of the coalmasters issued circulars intimating an increase of 6d. per ton in prices of house coal. The demand had been very brisk during the cold weather that prevailed up till that time; but the last few days have been exceptionally mild, and the inquiry is, therefore, not so active. The prices of shipping coal now current are the highest for the present year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The South Wales Coal Trade.

TRADE at the South Wales ports is very brisk, and tonnage plentiful; in fact, the docks have as much work as they can possibly do. One day this week Cardiff alone cleared forty-two large steamers, and despatched over 70,000 tons of coal. The quantity of coal, coke, and patent fuel shipped foreign from the South Wales ports last week totalled 447,050 tons, an increase over the corresponding period of last year of 11,500 tons. At this rate the high estimate given lately for the year is likely to be exceeded. Cardiff exported 277,170 tons of coal, 800 tons coke, and 6300 tons of patent fuel; principal customers were River Plate, 11 cargoes, amounting to 37,000 tons; and Port Said 5 cargoes, totalling 25,200 tons. Newport shipments were 63,127 tons coal, 45 tons coke, and 2300 tons patent fuel; Marseilles with 3 cargoes, amounting to 9600 tons, being principal customer. Newport showed a record shipment for November of 382,903 tons. Swansea shipped 67,869 tons of coal, and 9500 tons patent fuel. Rouen took eleven cargoes of coal from Swansea, totalling 13,300 tons. Alexandria was the destination of 2800 tons patent fuel. Port Talbot shipped 16,486 tons of coal, 2500 tons coke, and 500 tons patent fuel. The latest statement on 'Change, Cardiff, this week was that the coal market remains in a very firm condition, and stems are full. It is extremely difficult, states a leading member, to get any coal for prompt shipment, collieries having as much as they can possibly do to fulfil their obligations. For backward shipments price rules high, and as much as 17s. has been asked for January shipment; buyers, however, are chary of buying for forward shipment, and are inclined to believe that after the holidays prices will rule easier.

Latest Cardiff Coal Prices.

Best large steam coal, 16s. 3d. to 16s. 9d.; best seconds, 15s. 6d. to 16s.; seconds, 14s. 6d. to 15s. 3d.; drys, 15s. to 15s. 6d.; best washed nuts, 12s. 6d. to 13s.; seconds, 11s. 6d. to 12s.; best peas, 11s. 6d. to 11s. 9d.; seconds, 10s. 6d. to 10s. 9d.; best smalls, 10s. 3d. to 10s. 9d.; best ordinaries, 9s. 6d. to 9s. 9d.; seconds, 8s. to 9s.; inferiors, 7s. to 7s. 6d. Monmouthshire semi-bituminous: Best large, 15s. to 15s. 3d.; best ordinaries, 14s. 9d. to 15s. 3d.; seconds, 13s. 3d. to 13s. 6d.; inferior sorts, 12s. 6d. to 12s. 9d. House coal: Best, 16s. to 16s. 6d.; best ordinaries, 13s. 6d. to 14s. 6d.; seconds, 11s. to 13s.; No. 3 Rhondda, 16s.; brush, 13s. 3d.; smalls, 11s. to 11s. 3d.; No. 2 Rhondda, 13s. to 13s. 3d.; through, 9s. 6d. to 10s. 3d.; smalls, 7s. 3d. to 7s. 9d. Patent fuel: 15s. 3d. to 15s. 9d. Coke: Furnace, 17s. to 18s.; foundry, 22s. to 23s.; special, 28s. Pitwood is easier, owing to large cargoes coming in: price, 21s. to 21s. 6d.; a little higher at Newport.

Anthracite.

In the Swansea market there is a good deal of animation, the usual rush being shown to clear before the holidays. All kinds of coal are in strong demand. Latest quotations are:—Best anthracite for malting, 20s. to 21s. 6d.; second malting, 16s. 6d. to 17s. 6d.; big vein, 15s. 6d. to 16s. 3d.; red vein, 11s. 6d. to 12s. 6d.; cobbles, 18s. 6d. to 19s. 6d.; nuts, 22s. to 24s.; peas, 14s. to 14s. 6d.; rubbly culm, 6s.; duff, 5s. to 5s. 3d. Steam coal: Best, 15s. 9d. to 16s. 6d.; No. 3 Rhondda, 15s. 6d. to 16s. 6d. Patent fuel, 13s. 6d. to 13s. 9d.

Explosion on a Steamer at Port Talbot.

I regret to record a very serious explosion on board the Italian barque Megly at Port Talbot this week. The vessel had completed loading a cargo of coal for Chili, and it is supposed that the explosion occurred through coal gas accumulating in the hold. Seven of the crew were very seriously injured.

Colliery Disputes.

Several minor disputes were settled at the last meeting of the Conciliation Board, and a few remain, but are not expected to continue.

Liquid Air for Miners.

Mr. Henry Davies recently demonstrated the ease with which liquid air can be conveyed into workings—another welcome addition in aid of the collier in explosions.

The Iron and Steel Trade.

Only partial briskness continues, and in some quarters only four or five days' work have constituted the week's total. At Cyfarthfa "lighting up" only began on Tuesday evening. The chief works are fairly supplied with orders. Dowlais has a large order in hand for steel sleepers for South Africa. At the Goat Mill the output of steel rails was below the average. A heavy section is in hand for foreign contract; furnaces moderately brisk. The new engine building in front of the Dowlais house will be supplied with twenty-four boilers. A tolerable quantity of orders for miscellaneous iron is held, and the engineering, fitting, and mechanical branches are in full operation. During the week a quantity of old rails has been received at Newport from Southampton, also some scrap steel, and from Antwerp and Rotterdam 4501 tons of billets and bars. Swansea has been importing pig iron largely. Last week 3000 tons were received. Hematite pig is in demand and prices advancing. On 'Change, Swansea, this week the following quotations were given out:—Bessemer pig iron, mixed numbers, 78s. 4d. Middlesbrough, 62s. 10s. Scotch, 67s. Welsh hematite, 68s. Steel rails, unchanged: Heavy, £6 10s.; light, £6 17s. 6d. Steel bars: Siemens, £5 15s. Bessemer, £6 to £6 2s. 6d. Iron ore at Cardiff and Newport: Rubio, 22s. to 22s. 6d.; Almeria, 21s. 9d. to 22s. Latest steel quotations: Heavy rails, £5 12s. 6d.; light, £6 2s. 6d. Bars: Siemens, £6 5s.; Bessemer, £6 2s. 6d. Other Swansea quotations are: Block tin, £195 5s. Lead £20 5s. Copper, £106 15s. Silver, 32 1/16d. per oz. Spelter, £28 2s. 6d.

Tin-plate Trade.

The retirement of Mr. Joseph Mayberry from the active management of the Old Castle Tin-plate Works, Llanelly, is the subject of regret in the district, but it is understood that he will retain his position as chairman of directors. The works rank among the best-equipped and flourishing of the district. The trade generally remains in a busy condition. Batoum and Odessa are again being represented at the docks. Last week the works were busy in all districts, and it was reported that ample orders were in hand. Llanelly has been sending plates largely to Swansea to make up cargoes, and all mills are busy. During the week Swansea despatched 107,776 boxes, and received from works 97,055 boxes. Stocks are down to 129,566 boxes. Swansea Metal Exchange quotations this week were as follows:—Ordinary plates: Bessemer 1 C., 20 by 14, 112 sheets, 15s; Siemens, 15s. 1½d. C A roofing sheets, £11 10s to £11 15s. per ton; finished black plates, £11 5s. The Caerleon dispute remains, but a report is expected to be given on Saturday, when definite steps are expected to be taken. At the Old Lodge Works, Llanelly, a large outlay is going on in compounding the engines.

Matches in the Mine.

Notwithstanding the terrible experience colliers have had, cases of gross carelessness continue. Last week, in the Aberdare district, a collier was fined £2 and costs for having matches in his possession in the colliery.

NOTES FROM GERMANY.

(From our own Correspondent.)

Expansion of Iron Trade in Silesia.

ALL the accounts received show a further increase in demand for and employment of raw as well as for finished iron. The Pig Iron Syndicate has again raised the prices for crude iron, and quotations for East and North Germany, both for hematite and for foundry pig No. 1, are M. 3 p.t. higher than previously. Hematite now stands at M. 91 p.t., and foundry pig No. 1 at M. 89 p.t. free place of consumption.

Activity on the Rhenish-Westphalian Market

The position all round continues excellent, and the iron and steel works are more actively employed than they have been at any time for several years past. Prices generally are satisfactory, and there is a tendency to move upwards in many branches. Output is heavy at all the different establishments, though hampered a good deal by the want of workmen. The Wire Rod Convention has raised the prices for wire rods M. 5 p.t. for the second quarter next year. The shops engaged in the manufacturing of railway requirements are very well occupied, and are looking forward to being strongly employed during the first quarter of 1907, as several orders for the State Railways are about to be placed, and the outlook generally is so bright in this branch of the iron trade that the shops do not care for foreign orders at present, and are reported to have declined some contracts for abroad.

The Coal Trade in Germany.

Not much change has taken place in the position of the coal and coke trade over here; if anything an improvement can be reported, and an exceedingly stiff tone prevails all round. The Silesia supplies in engine coal are still insufficient, and house coal had to be taken instead. The falling off in the demand for house fuel last month, which was caused by the exceptionally mild weather, has not been disagreeably felt by coalowners owing to the fact that house coal had to be bought for industrial purposes. The condition of the coke trade continues excellent as before.

The Austro-Hungarian Iron Market.

In all sorts of pig iron the scarcity previously complained of has continued, causing considerable inconvenience in several instances. For the present an advance in quotations has not taken place, but after the New Year the tariffs of the South Railway are to be raised, and this will probably cause an advance in the prices for pig iron. During the week now past both bars and sectional iron, and also wire rods, have been in good request; plates continue in excellent demand, and there is not likely to be an abatement for some time to come, as the Austrian wagon factories have secured Government orders for 4500 wagons, which will keep them well occupied till the autumn of 1907. At the machine and tool shops regular employment is reported to prevail. The want of coal in Austria has compelled dealers to purchase large quantities of English coal, which is readily consumed by the railways and industries in the south of Austria. Bohemian brown coal is strongly called for, and some sorts were raised in price, and forward orders can hardly find acceptance because further advances are anticipated. On the Hungarian coal market both output and consumption have improved upon the week. The pits, by granting higher wages, and by adding men employed in other industries to their working staff, have been able to increase the number of colliers lately; if the newly gained hands can be retained for some time, a rise in output of coal may be counted upon for next quarter. House coal was rather better inquired for than previously, although the weather continues mild.

The French Iron Market.

The tendency of prices is upwards in the French iron industry, and occupation in the different departments continues regular and satisfactory. In coal and coke a very good trade is done; some contracts in coke for delivery next year have already been booked at the raised price of 26·50f. p.t. Quotations for house and engine coal have not changed, but they are expected to rise as soon as the weather gets cold.

Finished Iron Animated in Belgium.

Orders come in freely and regularly at the various establishments, and compared to previous weeks increasing life could be noticed in the finished iron and steel trade. In a number of cases contracts could only be accepted at very long terms of delivery, and good activity during the greater part of next year has already been secured to the majority of shops. Nominally, iron and steel bars are still standing at 160f. to 162·50f. p.t. for inland, and 166·25f. to 168·75f p.t. f.o.b. Antwerp, for foreign consumption, but higher prices are already being realised very frequently. Girders are extremely firm at 143·75f. p.t. for export. In the Belgian coal industry the business done upon the week has been quiet but firm, and house coal was well inquired for in spite of the mild weather.

LIVERPOOL ENGINEERING SOCIETY.—The annual dinner will be held at the Adelphi Hotel, Liverpool, at seven o'clock on Thursday evening, the 17th January, 1907.

THE NEWALL DATA CARD (No. 1.).—We have received from the Newall Engineering Company, Limited, of Warrington, a useful card, which gives in tabulated form metric equivalents of an inch from 1 mm. to 250 mm. The figures are neatly printed in bold figures on a card 6in. by 9in. A vertical column in black-faced type reads from 0 mm. to 25 mm., whilst a horizontal column, also in black type, reads from 0 mm. to 9 mm. The whole series of equivalents in decimals of an inch up to four places are given in the contained area. This card is the first of a series containing general workshop information which the firm proposes to publish, and we have no doubt that the complete series will form a very useful collection.

ALMANACS, DIARIES, &c., FOR 1907.

THE first batch of these seasonable publications has reached us. A leather covered pocket book and diary from Hayward-Tyler and Co., Limited, 99, Queen Victoria-street, E.C., contains eighty-seven pages, and there is much useful information on the subject of water supply. A copy of this book will be sent to readers of THE ENGINEER on receipt of professional or trade card, or note heading. The Brush Electrical Engineering Company, a similar but smaller note book and diary which contains a £1000 accident insurance coupon. The Dermatene Company, Limited, 95, Neate-street, London, has prepared for distribution amongst its friends and clients a small rule with English and metrical measurements. Shand, Mason and Co. have issued a wall calendar printed in black and red. The *Chemical Trade Journal*, as usual, issues a tear-off monthly wall calendar. Barclay, Sons and Co., Limited, Kilmarnock, a neat wall calendar with tear-off monthly slips. Messrs. George Cradock and Co., Wakefield, have selected a very charmingly printed seascape to combine with the monthly wall calendar. The production altogether is most tasteful and effective. The Gloucester Railway Carriage and Wagon Company, Limited, for the twelfth year publish the "Gloucester Diary and Directors' Calendar," the main features of which have frequently been mentioned by us. Mr. John Hetherington, 39A, King William-street, London, E.C., adheres to his usual wall calendar with large clear figures.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE STERN-SONNEBORN OIL COMPANY informs us that it is removing its offices from 57, Gracechurch-street, E.C., to Royal London House, 16, Finsbury-square. The latter will be its address from January 1st, 1907.

MR. FRANK ROBINSON, who has been appointed sole agent for Birmingham and the Midlands for the Ebbw Vale Steel, Iron, and Coal Company, Limited, has taken offices in the Exchange Buildings, Birmingham, which he will open January 1st, 1907.

JESSOP AND APPLEBY BROTHERS, Leicester and London, Limited, and the Glasgow Electric Crane and Hoist Company, have amalgamated under the title of Applebys Limited, with head offices, 56, Victoria-street, London, S.W. The new firm will make giant cranes, shipbuilding berth equipments, lifting appliances of all types and powers, &c. Mr. Edmund G. Appleby, late chairman of the firm of Jessop and Appleby Brothers, Leicester and London, Limited, is the managing director of the new concern.

THE ENGINEERING STANDARDS COMMITTEE.—We have received from the Engineering Standards Committee a copy of tables of British standard screw threads. The Publication Committee have decided to issue these tables in this form so as to render them readily accessible to the engineering public. The Committee have arranged for them to be available in two forms:—(*a*) In pamphlet form; and (*b*) mounted on card and varnished for use in drawing-offices, tool-makers' department, stores, &c.

INSTITUTION OF CIVIL ENGINEERS—GLASGOW ASSOCIATION OF STUDENTS.—At a meeting of this body, held on the 17th inst. in the Institution Rooms, Bath-street, Mr. M. Macpherson, vice-president, in the chair, Mr. James Lowe, Assoc. M. Inst. C.E., of the Glasgow Corporation Gas Department, read a paper on "Gas Supply." The author dealt with gasworks construction and equipment generally, but cited many illustrations from the Provan Gasworks. Gas plant generally, from the chemical and engineering standpoints, was first dealt with, followed by descriptions of the many mechanical and labour-saving appliances used in modern gasworks. The structural features of gasworks, with special reference to the design and construction of gasholders, were then treated of, and an interesting discussion followed.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE.—The annual dinner of the West of Scotland Iron and Steel Institute was held on the evening of the 13th inst. in the Windsor Hotel, Glasgow. Mr. T. B. Rogerson, President of the Institute, occupied the chair, and the company numbered close on 500. In proposing the toast of "The West of Scotland Iron and Steel Institute," Mr. Bennett H. Brough, secretary of the Iron and Steel Institute, expressed his appreciation of the valuable work which the Society had done during the past year. Their membership was higher than it had been during the fourteen years of the Society's existence. They started in 1893 with 153 members, and that number had steadily advanced to 411. The membership embraced those connected with the blast furnaces, the iron rolling mills, steel works, and kindred industries, and they were now endeavouring to get into the Institute their friends the foundrymen, who were a very large part of the industry of iron and steel making in the West of Scotland.

GLASGOW TECHNICAL COLLEGE SCIENTIFIC SOCIETY.—At the fifteenth annual dinner of the Glasgow and West of Scotland Technical College Scientific Society, held in the Grosvenor Restaurant, Glasgow, on the 15th inst., Mr. W. W. Lackie, the president of the Society, presiding, Lord Provost Bilsland, in replying to the toast of the "Glasgow Corporation," said it was highly satisfactory to know that the Governors of the College were now to have the buildings completed. It was a splendid thing for Glasgow that in all branches of technical education the facilities were so excellent, and that they were being taken advantage of to such a great degree. The Weaving College, the School of Art, the Technical College, were all filled with students eager to take advantage of the facilities offered. They had been celebrating the jubilee of the inventions of such men as Bessemer and Siemens, and he did not doubt that in after days they would celebrate names equally great. They of the Corporation were deeply interested in many of the subjects which engaged the attention of scientific men. In order to help on the purification of the city atmosphere they sold electricity and gas to power users for industrial purposes at a figure which just covered the cost of production. Mr. R. D. Munro, in proposing the "Technical College," urged that students of the College should be allowed to get degrees without the necessity for mechanical attendance at University classes, for studies which they had already mastered.

CONTRACTS.—An order for turbo generators of a total capacity of 7500 horse-power has been placed by the Rand Central Electric Works, Limited, with Siemens Bros. Dynamo Works, Limited, —Messrs. John Abbot and Co., Limited, Gateshead-on-Tyne, have recently been entrusted with the contract for a new caling staith for the Hartlepool docks of the North-Eastern Railway Company. This staith, when completed, will be 1260ft. long and 84ft. broad at the centre portion, and will require in its construction about 1500 tons of structural steel, irrespective of the timber uprights, decking, and coaling shoots. The same company is at present completing the shipment of four hydraulic portable quay cranes for Durban Harbour, to the order of the Agent General for Natal. —The Portsmouth Borough Council have accepted the tender of Messrs. Johnson and Phillips, Limited, for electrically driven pumps, switchboards, and cables for the Southsea drainage scheme.—Joseph Wright and Co., of Tipton, have just received one from the Barrow Hematite Steel Company, for a water softening and heating plant to deal with 15,000 gallons per hour, and have orders for heating and purifying plants at the present time from Messrs. Steel, Peech, and Tozer, Messrs. Cammell, Laird and Co., third installation; the Universal Tube Company; Messrs. Robey and Co.; and several other firms; as well as for Berryman calorifiers for the Mullingar Asylum, Selby Waterworks, Gibson-street Baths, Walkergate Fever Hospital, Middlesex Hospital, Cork Waterworks, Burnley Infirmary, and other installations.

LAUNCHES AND TRIAL TRIPS.

BILLITER, clear hold turret steamer; built by Doxford and Sons, Limited; to the order of Messrs. John Sunley and Co.; dimensions, 366ft., 50ft. by 21ft. 9in.; engines, triple-expansion, 24in., 41in., 68in. by 45in.; launch recently.

HOLLAND, turret steamer; built by Messrs. Doxford and Son; to the order of Messrs. F. Drughorn, Limited; dimensions, 350ft. by 50ft.; engines, triple-expansion, 25in., 41in., 66in. by 45in.; a mean speed of over 10 knots was attained; trial trip recently.

O. A. KNUTSEN, steel screw steamer; built by Craig, Taylor and Co., Limited; to the order of Mr. Knut Knutsen; dimensions, 352ft., 51ft. by 25ft. 1in; engines, triple-expansion, 24½in., 40.n., 66in. by 45in., pressure 180 lb.; constructed by John Dickinson and Sons, Limited; launch, November 15th.

MAGDALA, steel screw cargo steamer; built by David and William Henderson and Co.; to the order of Messrs. Maclay and McIntyre; dimensions, 415ft., 52ft. by 29ft. 6in.; engines, triple-expansion, 26in., 43in., 71in. by 48in., pressure 180 lb.; constructed by builders; the vessel is a sister ship to the Oceana; launch, November 16th.

PICTON CASTLE, steam fishing trawler; built by Mr. W. Walker, Maryport; dimensions, 120ft., 22ft. by 12ft. 6in.; constructed by Messrs. McCall and Pollock; launch, November 17th.

DUFFIELD, turret steamer; built by Wm. Doxford and Sons, Limited; to the order of Northern Petroleum Tank Steamship Company; dimensions, 366ft., 50ft. by 26½ft.; to carry 6600 tons deadweight; engines, triple-expansion, 25in., 41in., 66in. by 45in.; constructed by builders; launch, November 20th.

THELMA, steel screw cargo steamer; built by Laxevaags Engineering and Shipbuilding Company; dimensions, 270ft., 38ft. by 17ft. 8½in.; engines, triple-expansion, 19½in., 31in., and 51in. by 36in., pressure 180 lb.; constructed by builders; a mean speed of 12 knots was attained; trial trip, November 20th.

VENTURE, steam trawler; built by Earle's Shipbuilding and Engineering Company; to the order of Mr. G. Blashill, Hull; dimensions, 135ft., 22ft. 4in. by 13ft. 4in.; engines, triple-expansion; the vessel is constructed with a whaleback; launch, November 20th.

BEN LOMOND, steel screw steamer; built by Wm. Gray and Co., Limited; to the order of Messrs. John Morrison and Son, Newcastle; dimensions, 331ft., 46ft. 9in. by 23ft. 6in.; engines, triple-expansion, 23½in., 38in., 64in. by 42in., pressure 180 lb.; constructed by builders; a speed of 11 knots was averaged; trial trip, November 22nd.

LINDEN FELL, steel screw steamer; built by Irvine's Shipbuilding and Dry Docks Company; to the order of the Hessler Shipping Company, Limited; dimensions, 336ft., 47ft. by 24ft. 10in.; engines, triple-expansion, 24in., 33in., 64in. by 42in., pressure 160 lb.; constructed by Richardsons, Westgarth and Co.; mean speed, 11¼ knots; launch, October 18th; trial trip, November 26th.

HEBREDALE, screw steamer; built by R. Craggs and Sons, Limited; to the order of the Hebredale Steamship Company; engines, triple-expansion, 25in., 41in., 67in. by 45in., pressure 180 lb.; constructed by Blair and Co., Limited; the trials were entirely satisfactory; trial trip, November 27th.

ARAWA, steel twin screw cargo and passenger steamer; built by Swan, Hunter, and Wigham Richardson, Limited; to the order of Shaw, Saville, and Albion Company, Limited; dimensions, 460ft., 60ft. by 42ft. 6in.; engines, two sets triple-expansion, pressure 205 lb.; constructed by Wallsend Slipway and Engineering Company; passenger accommodation is provided for 40 first-class, 60 second-class, and 120 third-class; launch, November 29th.

SUNLIGHT, sailing vessel; built by Messrs. Napier and Miller; to the order of Lever Brothers, Limited; dimensions, 230ft. by 37ft.; to carry oil in bulk or general cargo; steam donkey pump for dealing with oil cargoes has been provided; launch, November 29th.

INVERTAY, steel screw steamer; built by W. Dobson and Co., Low Walker-on-Tyne; to the order of Messrs. Law, Leslie and Co., dimensions, 379ft., 50ft. by 28ft.; engines, triple-expansion. 26in., 42in., 72in. by 48in., pressure 180 lb; constructed by North-Eastern Marine Engineering Company; a mean speed of 11½ knots was attained on the measured mile; trial trip, December 1st.

GOATHLAND, steel screw steamer; built by Tyne Iron Shipbuilding Company; to the order of Mr. Christopher Harwood; dimensions, 341ft., 48ft. by 24ft. 4½in.; engines, triple-expansion, 24in., 40in., 65in. by 42in., pressure 180 lb.; constructed by J. Dickinson and Sons, Limited; launch, December 3rd.

WESTLAND, coal steamer; built by Messrs. Rykee and Co.; to the order of the Shipping and Coal Company, Rotterdam; to carry 1700 tons on light draught; engines, 17½in., 28in., 45in. by 36in., pressure 180 lb.; constructed by Wilton's Engineering and Slipway Company; a speed of over 10 knots was attained on the measured mile; trial trip, December 4th.

CAMPHILL, steamer; built by Ropner and Son; to the order of Macbeth and Co., Limited, Glasgow; to carry 6800 tons on Lloyd's s.f.b; engines, triple-expansion; constructed by Blair and Co., Limited, Stockton; the trip was in every way satisfactory; trial trip, December 7th.

HENRIK IBSEN, steel screw steamer; built by Sir Raylton Dixon and Co., Limited; to the order of Hern W. Torkildsen; dimensions, 396ft. 9in., 52ft. 8½in., 28ft. 4in.; to carry 7500 tons; engines, triple-expansion, 25in., 41in., 67in. by 45in., pressure 180 lb; constructed by North-Eastern Marine Engineering Company; the trials passed off most successfully; trial trip, December 8th.

LINDENFELS, steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of a Bremen firm; dimensions, 436ft., 55ft. 3in.; to carry 8500 tons deadweight; engines, four crank quadruple; the engines worked without a hitch; trial trip December 11th.

VENTURE, steam trawler; built by Earle's Shipbuilding and Engineering Company; to the order of Mr. G. Blashill, Hull; a speed of 10¾ knots was attained; trial trip, December 12th.

UTGARD, steel screw steamer; built by Northumberland Shipbuilding Company, Limited; to the order of a Bremen firm; dimensions, 372ft., 48ft., by 30ft. 10in.; to carry 7300 tons deadweight; engines, triple-expansion, 25in., 41in., 69in. by 48in., pressure 180 lb.; constructed by Richardsons, Westgarth and Co.; a speed of 11½ knots was easily attained; trial trip, December 14th.

CLEARPOOL, trunk steamer; built by Ropner and Son, Stockton; to the order of the Pool Shipping Company; dimensions, 370ft., 51ft. by 28ft. 5in.; to carry 7000 tons on Lloyd's s.f.b; engines, triple-expansion, 2100 horse-power, pressure 180 lb.; constructed by Blair and Co., Limited; launch, December 14th.

RAUENFELS, steel screw steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of a Bremen firm; dimensions, 436ft., 55ft. 3in.; to carry 8500 tons deadweight; engines, four-crank quadruple-expansion; constructed at Neptune Works; launch, December 14th.

IRMINGARD, finely moulded steamer; built by Northumberland Shipbuilding Company, Limited; to the order of a Bremen firm; dimensions, 372ft., 48ft. by 30ft. 10in.; to carry 7300 tons deadweight on 25ft. 0½in.; engines, triple-expansion, 25in., 41in., 69in. by 48in., pressure 180 lb.; constructed by Richardsons, Westgarth and Co.; launch, December 14th.

MANICA, steel screw passenger and cargo steamer; built by Sir Raylton Dixon and Co., Limited; to the order of Empreza Nacional de Navegacao of Lisbon; dimensions, 233ft. 8in. by 33ft. 2in. by 17ft.; to carry 800 tons on a light draught; engines, triple-expansion, 15½in., 25in., and 41in. by 27in., pressure 180 lb.; constructed by North-Eastern Marine Engineering Company; launch, December 14th.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS**, *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

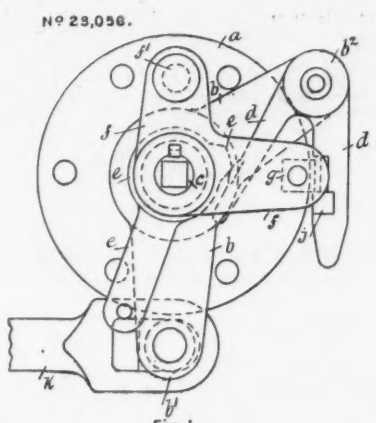
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

23,056. November 10th, 1905.—IMPROVEMENTS IN OR IN CONNECTION WITH CORLISS VALVE GEAR, John Edward Robinson, Ernest Robinson, and Edward Robinson, Field Works, Openshaw, Manchester.

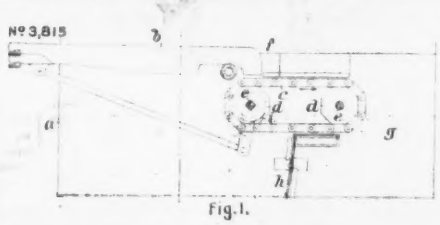
This invention relates to improvements in or in connection with bell-crank rocking Corliss valve gear. The primary object of the invention is to simplify the construction by reducing the number of working parts. There are two figures. Fig. 1 is a front view of the improvements as applied to the cylinder facings. A sleeve *a* is secured to each of the steam chest facings that are at the side of and near each end of the upper portion of the cylinder, and pass the valve spindles *c* through the sleeves; the outer ends of these



sleeves are reduced in diameter, and a bell-crank lever *b* is placed on each. One arm *b* 1 of one of the bell-crank levers is connected to a corresponding arm on the opposite end of the cylinder case and to the excentric rod *k*. The other arm *b* 2 carries the tripping lever *d*. A cam *e* is placed on the sleeve *a*, and the governors are connected to the cam for the purpose of cutting off steam at various parts of the stroke of the engine. A bell crank lever *f* is placed on and secured to the valve spindle in front of the cam. One arm of this bell-crank lever is connected to the dashpot by a rod connected to the pin *f* 1, and the other arm, in which a rectangular tripping steel is fitted, engages with the tripping lever *d*, in which a tripping steel *j* is fitted; both of the tripping steels are secured by screws, and can be turned over when the edges are worn.—*November 21st*, 1906.

3815. February 16th, 1906.—IMPROVEMENTS IN OR CONNECTED WITH MECHANICAL STOKERS, John Vicars, sen., Thomas Vicars, and John Vicars, jun., all of Earlestown, Lancashire

This invention relates to mechanical stokers having movable fire-bars, chains, or the like, which convey the fuel gradually from front to back of the furnace. Hitherto in this type of stoker there has been a liability that, as the mass of fuel passes over the back ends of the bars either on to fixed or similarly movable auxiliary grates, openings or spaces are formed in the fuel, thus allowing the passage of large quantities of cold air causing imperfect combustion and smoke and cooling the boiler. The object of this invention is to provide means whereby the openings in the fuel mass may be prevented. There are three figures. Fig. 1 is a

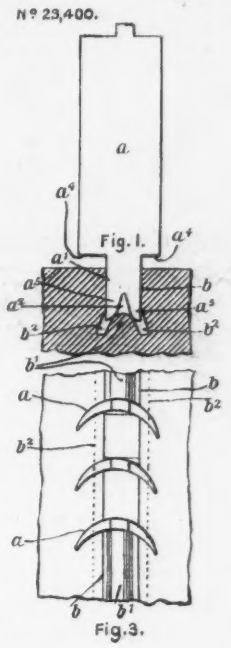


longitudinal section; *a* are the walls of a furnace, *b* the main travelling grate of reciprocating bars, *c* is a small auxiliary travelling grate consisting of chains passing round pulleys or wheels *d* carried on shafts *e* and caused to move in the direction of the arrow, so that the chains of the upper part of their travel move in the opposite direction to the travel of the fuel on the main grate *b*, so that such auxiliary grate *c* instead of, as hitherto, drawing away the fuel from the end of the main grate as it passes over at about *f* and forming holes thereabouts, tends to press back such fuel against the end of the main grate, thus maintaining a comparatively thick mass of fuel in that position and preventing the formation of holes. Owing, however, to the greater propelling power of the main grate, the pressure of the fuel delivered from such main grate will gradually force back the exhausted cinder and clinker to the back of the auxiliary grate *c*, whence it falls into the ashpit *g*, from which it can be removed from time to time through the door *k*. The grate *c* is caused to move by ratchet and pawl mechanism *i*.—*November 21st*, 1906.

TURBINES.

23,400. November 14th, 1906. — IMPROVEMENTS IN TURBINES, Messrs. Bellis, Morcom, Ltd., and Alexander Jude, Ledsam street Works, Birmingham.

This invention relates to improvements in the construction of guide blades and vanes, and to means for assembling them and for securing them to the stators and rotors respectively of turbine motors. There are thirty-two figures. The principle of connection involves the employment of a ring groove with an undercut side formed in the stator or rotor, and means for diverting transversely into the undercut portion of the groove the fangs of the blades which it is desired to secure to the stator or rotor in which the groove is formed. Figs. 1 and 3 show one form of construction. A strip of metal of section suitable to form a guide blade or vane *a* is stamped or machined to a shape such as is indicated the breadth of the portion a^1, which forms the shank of the vane, being lessened by the removal of the thin edges, and a notch a^2 being formed for the purpose of making a riveted attachment to the shrouding in the usual way. The groove *b* into which the shank a^1 is intended to be inserted has a transverse section, there being a ridge b^1 left in the centre of the bottom of the groove by turning a deep and narrow groove b^2 on each side thereof. If a guide

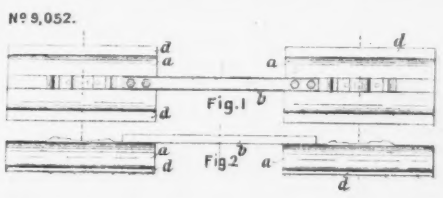


blade or vane formed as described is forced or driven into the groove until the shoulders a^4 a^4 come in contact with the surface of the stator or rotor, the fangs a^5 a^5 will be splayed into the undercut side grooves b^2 b^2, and thus clinch the connection. Between the guide blades or vanes a filling or distance piece, whose section has a profile like that of the shank a^1, can be similarly clinched.—*November 21st*, 1906.

RAILWAYS AND TRAMWAYS.

9052. April 17th, 1906.—IMPROVEMENTS IN OR CONNECTED WITH METAL SLEEPERS FOR RAILWAYS, *Albert Goebel, 22, Tiefenbachgasse, Vienna, Austria.*

This invention relates to metal sleepers of the kind in which there are two separate hollow bodies or sleeper heads which are united by a connecting piece and are provided with openings, and the bases of which are extended to form longitudinal ribs or flanges serving to anchor the sleeper heads in the ballast. There are fourteen figures. An iron sleeper of this kind is shown in Figs. 1 and 2 in plan and side elevation respectively. The sleeper consists of three separate parts, viz., two hollow heads *a* which lie beneath the rails of the track, and a coupling piece *b* for uniting these two parts. The sleeper heads *a* can be made of iron or steel and can be cast, pressed in moulds, or rolled. Their section may be varied. In all cases, however, it forms a closed figure, the base of which projects a suitable distance at both longitudinal edges of the sleeper heads. The ribs *d* extending beyond the base of the sleeper head, in the case of sleeper heads



which are cast, form one piece therewith. The sleeper heads so produced are open at both ends and are filled with ballast, and are embedded in the ballast of the track after they have been united by the coupling piece *b*, this being preferably effected at the place where they are to be laid. The connection of the piece *b* with the sleeper heads is effected by bolts, for which purpose the channel iron or angle iron *b* is placed on the sleeper head, and also the upper surfaces of the sleeper heads *a* are provided with holes for the bolts, in which arrangement the distance apart of the bolt holes in the ends of the coupling piece *b* is such that the normal gauge or the necessary widening of the gauge or curves is thereby determined. Sleepers of the kind described, by reason of their weight and the way in which they are anchored in the ballast, offer the necessary resistance to lifting, and by reason of their having double the number of end surfaces, as compared with ordinary undivided sleepers, they also offer double the resistance to lateral displacement of the track, so that even with the most rapid transit of vehicles over the track great stability and a steady support of the track are ensured. Since, moreover, sleepers of this kind can be weighted with inexpensive material, such as road metal or the like, there is no increase of cost in this respect.—*November 21st*, 1906.

ROAD MOTOR VEHICLES.

9960. April 28th, 1906.—IMPROVEMENTS IN RESILIENT WHEELS OF MOTOR CARS AND OTHER ROAD VEHICLES, Tom Oldfield and Joseph Arthur Schofield, both of Central Ironworks, Boothdown, Halifax.

This invention relates to resilient or spring wheels for motor cars and other suitable road vehicles such as are constructed with two concentric rims, or with an extended hub and outer rim or tire having springs. There are eight figures. Fig. 1 is a side elevation, partly in section, of the improved resilient or spring wheel suitable for motor cars or other road vehicles. An outer rim or tire E is fitted concentrically about an inner rim or extended or flanged hub F formed of aluminium or aluminium alloy to ensure lightness. This inner rim F may have radial arms or ribs G for strengthening purposes, while upon or near its outer edge or rim are a number of projections or lugs H, within each of which is a suitable recess or slot J. Within each recess is a nut K supported and made to swivel within said recess, by pivot bolts L screwed into and projecting from each side of the lugs or projec-

tions. A radial retaining bolt M, screwed at each end, passes loosely through each swivel nut K, and is secured to or suspended from a rocking link or arm N pivoting at P upon a bracket R bolted to the outer rim E. Upon the retaining bolts or tubes M are mounted two spiral or the like springs, one spring S is placed between the rocking arm or link N and the swivel nut K, and the other spring T between the swivel nut and a disc nut U screwed upon the other end of the retaining bolt. In this manner,

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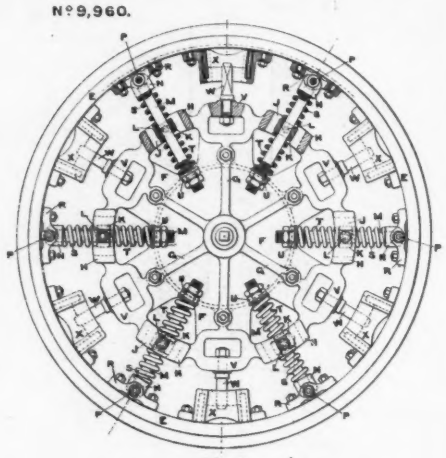

Fig. 1.

whatever the direction of displacement of the rim or hub centres, compression or cushioning of one or other of the springs is the result. Interposed between the lugs H is another series of projections V carrying radial bolts W which project within a corresponding number of guide boxes X attached to the inner side of the outer rim or tire E; these bolts or studs are radially situated, and are for preventing lateral shifting of the rims, and under certain circumstances serve to transmit the drive to the outer rim. —*November* 21*st*, 1906.

SMALL-ARMS.

23,533. November 15th, 1905.—IMPROVEMENTS IN AUTOMATIC OR SEMI-AUTOMATIC RIFLES AND OTHER SMALL-ARMS, Thomas R. R. Ashton, 28, Gower-street, Bloomsbury, London.

This invention relates primarily to rifles in which the breech bolt is operated automatically by the pressure of the powder gases admitted to a piston which is connected with a straight pull adapted to act on the bolt, and it is chiefly intended for rifles in which the breech bolt has a rotary action, but the invention is applicable also to other small-arms. There are thirty-two figures. Fig. 1 is a left-hand side view of the rifle without the stock. 1 indicates the gun barrel, 2 the breech frame, 3 the gas cylinder, 4 the yoke fixed to the rear end of the piston-rod, 5 are the spindles fixed to the yoke 4 right and left of the cylinder, 6 are the helical springs coiled around the spindles, 7 is the semi-tubular rear part of the straight pull slide, 8 are the elastic side-arms of the same. Recesses are formed in the front ends of the side arms to receive the lugs on the yoke 4. Each lug is secured in the recess by a pin. The breech frame 2 has on its right and left side a pair of grooves, extending the whole length of the frame or breech. When the straight pull slide is in its extreme forward position, the semi-cylindrical or tubular part 7 of the same extends backwards

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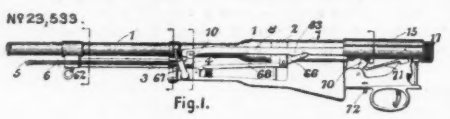

Fig. 1.

approximately as far as the rear end of the magazine, and when the straight pull slide is detached, the arms 8 occupy a divergent position. For attaching the arms 8 to yoke 4, it is therefore necessary to press their free ends towards each other until they can be introduced between the arms 10 of the yoke. 15 is the dust cover. It protects the straight pull slide, and has at its base a pair of narrow flanges or guide rails situated below the base of the breech frame, and serving to guide the cover in a straight line. The dust cover is removable by withdrawing it longitudinally past the rear end of the breech frame, after a screw cap 17, which normally closes the screw-threaded rear extension of the latter, and serves as a stop-abutment for the dust cover, has been removed. A ring 62 forms a head for the valve spindle for opening or closing the gas duct from the gun barrel to the gas cylinder, also a lubricating cup for the gas cylinder. The cup is filled with cotton wool impregnated with oil, the bottom of the cup is perforated to communicate with the interior of the gas cylinder, and the outer end of the cup is closed with a screw. 66 and 83 are parts of a device for facilitating the extraction of the empty cartridge case. 67 is a device for lifting and lowering the lever 68 of the magazine platform. 70 is the hammer, 71 the hammer spring, and 72 a slide for locking the trigger mechanism.—*November* 21*st*, 1906.

MISCELLANEOUS.

23,566 November 16th, 1905.—IMPROVEMENTS IN THE GENERATION OF STEAM IN SUBMARINE BOATS, *Aktiengesellschaft der Maschinenfabriken von Escher, Wyss and Co., Zurich, Switzerland.—Date under International Convention, November 18th*, 1904.

The submarine boats hitherto built and to some extent found practical in various countries have in general been propelled on the water by explosion motors, and under water by electric motors receiving current from previously charged accumulators. The great weight of these accumulators and powerful explosion motors, as well as the large space they occupy, however, rendered the use of powerful motors in submarine boats impossible, so that hitherto the highest speed attained by a submarine boat has been on the water ten knots and under the water six knots, and hence they have been no match in speed for the quicker-going cruisers or torpedo boats. The use of aqueous vapour as near as possible a high constant pressure as motive power for the propulsion under water could hitherto not be resorted to, because the products of combustion could not be conveyed into the atmosphere, but had to be conducted into the sea, which continuously formed bubbles on the surface thereof. This invention consists essentially in the employment of a steam generator for burning gaseous fuel—hydrogen and oxygen—for propulsion under water, the products of combustion of which are condensed into water by direct contact with the surrounding water without producing bubbles on the surface. The employment of this kind of generator in submarine boats permits of using the same steam engines and aqueous vapour under high, and as near as possible a constant, pressure for propulsion under water as well as on the surface of the water, so that these engines can be made sufficiently powerful and yet light in weight to give the submarine boat fitted therewith under and on the water a speed which has hitherto not been attained.—*November* 21*st*, 1906.

23,596. November 16th, 1905.—IMPROVEMENTS IN THE CONSTRUCTION OF CRANK SHAFTS, Edmund E. Bentall and George C. Bingham, both of Heybridge, Maldon, Essex.

This invention relates to those built-up crank shafts for motive power engines and other purposes which are constructed of two end cranked parts provided with extended tapered crank pins adapted to fit into an intermediate connecting block or frame, and has for its object certain improvements in the construction and arrangement of the parts whereby crank shafts of any desired number of throws may be built up. There are four figures. Fig. 4 is a four-throw crank shaft with a central bearing. The end parts *a* are each coupled to an independent block or frame *d*,

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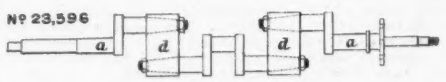


Fig. 4.

and these two latter are secured together by a third crank pin in the form of a straight bar having both its ends tapered or otherwise shaped so that they form elongations similar to those on the ends of the crank pins of the end pieces *a*, and are adapted to fit into the two blocks *d* and couple these together. In crank shafts of more than four-throw, the arrangements are combined or duplicated, other intermediate blocks besides the two connected to the end portions being employed where necessary. The crank pins may be arranged at any desired angle to one another, and means adopted to prevent the extensions and the blocks or frames turning about one another.—*November* 21*st*, 1906.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

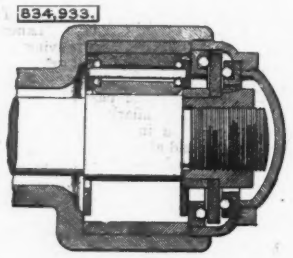
834,904.—MANUFACTURE OR TREATMENT OF STEEL ARMOUR PLATES, *R. A. Hadfield, Sheffield, England.—Filed April 14th*, 1906.

There is no illustration to this patent, which is sufficiently described by the last of four claims, which runs as follows:—The process of making steel armour plate, shields, and the like, consists in casting the same in a mould, slowly cooling the casting in a furnace, and thereafter removing and cleaning the casting; subjecting the casting for several days to a furnace temperature of from 900 deg. Cent. to 1100 deg. Cent. while in contact with carbonaceous material, and then allowing the plate to gradually cool down in the furnace; then heating the casting to from 700 deg. Cent. to 850 deg. Cent. and cooling slowly; repeating the last-named step and then cooling the casting to between 640 deg. Cent. and 690 deg. Cent., and quenching the casting in water; reheating to between 570 deg. Cent. and 640 deg. Cent. and cooling; repeating the last-named heating, and then quenching the casting; then taper-heating such casting to a temperature of from 700 deg. Cent. to 770 deg. Cent. at its face, tapering to from 400 deg. Cent. to 600 deg. Cent. at the back, and dipping or spraying with oil or water.

834,933. END-THRUST-RESISTING MEANS FOR BEARINGS, *J. A Perkins, Omaha Nebr.—Filed November 11th*, 1903.

The introduction of the steam turbine has called into existence

834,933.

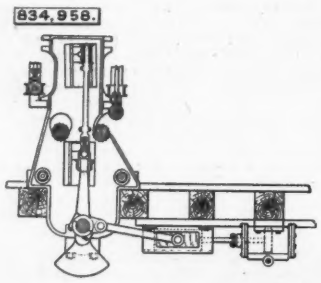


many inventions for taking up end thrust. This is one of them. The claims, of which there are six, are all for details, which are clearly shown in the engraving.

834,958. GANG-SAW MECHANISM, *T. S. Wilkin, Milwaukee, Wis.—Filed January 7th*, 1904.

This invention is intended to take up momentum and secure quick running at a high speed. There are seven claims, the last of which describes the invention very well. In combination with the main framework, sash, and actuating mechanism of a gang-saw mill, a shaft provided with counterbalance weights set to reach the downward limit of their throw as the sash reaches its highest point, and *vice versâ*; a second counterweight movable back and forth in

834,958.



a given plane at substantially right angles to the plane of movement of the saw frame or sash, and connections between the first and second counterweights, whereby the latter is brought to its medial position when the first is at its highest and lowest points and is moved inward toward the first when said first counterweight is on the same side of its carrying shaft as the second c unterweight, and is moved outward therefrom as the first counterweight passes to the opposite side of its shaft,

835,056. COMBINED GAUGE COCK AND SAFETY VALVE.—*A. C Calder, Richmond, Va.—Filed April 30th*, 1906.

In the United States gauge cocks are still used. This ioninvent

835,056.

consists in combining a gauge cock and a sentinel valve. There is one claim.

CATALOGUES.

SPENCER AND CO., Limited, Melksham Foundry, Melksham, Wilts.—Leaflets describing loam, sand, and mortar mills.

VAUGHAN PULLEY COMPANY, West Gorton, Manchester.—Catalogue and price list of details and specialities required in high-efficiency power-transmission plants.

BARFORD AND PERKINS, Peterborough.—Steam cooking, heating, and laundry machinery is dealt with in this catalogue, and there is a large variety of appliances.

THE MIRRLEES WATSON COMPANY, Limited, Scotland-street, Glasgow.—This book describes and illustrates vacuum pans, as made by this firm in connection with sugar machinery.

UNITED STATES STEEL PILING COMPANY, Chicago.—This pamphlet serves to convey a good idea of the numerous applications to which this steel sheet piling can be put.

MITCHELL'S EMERY WHEEL COMPANY, Bradford, Manchester.—Catalogue C is a compact well-illustrated and indexed pamphlet and price list of emery wheels and grinding machines for all kinds of purposes.

AUSTIN MOTOR COMPANY, Limited, Longbridge Works, Northfield, Birmingham.—In addition to views of the interior of these works, this catalogue furnishes a very complete illustrated description of the new Austin motor car.

DUDBRIDGE IRONWORKS, Limited, Stroud.—Catalogue of gas, oil, and spirit engines and gas-producing plants. The latter is designed on the pressure system. The engines are familiar to our readers. The book is neatly produced.

THOMAS ROBINSON AND SON, Limited, Rochdale.—Section VI. catalogue devoted to tenoning, mortising, and boring machines. To state that the manner of production of the book fully maintains this firm's standard is the highest praise we can bestow on it.

CAMPBELL AND CALDERWOOD, Soho Works, Paisley.—Two catalogues sent us by this firm are devoted respectively to land and marine machinery. The contents of the former include horizontal single-expansion and compound steam engines and vacuum pumps. The contents of the latter comprise single-cylinder screw engines, compound and triple-compound surface-condensing engines, and stern-wheel engines. The illustrations are wood-cuts, and very clear.

GEIPEL AND LANGE, 72A, St. Thomas-street, London.—An improved form of steam trap in which the special features are rapid discharge, sharp and definite shutting of the valve when all water has been discharged, and a rotating and self-grinding valve. In addition to these it has the well-known multiplication of expansion without the use of levers, and the hand-blow-through, as well as the other advantages common to the ordinary Geipel trap.

W. N. BRUNTON AND SON, Musselburgh, Scotland.—List of "Hoisting Wire Ropes." There are given in this list three constructions and three qualities in each construction, and also the ultimate stress of the rope, and the price per 100ft., and a ready method of calculating which construction is best adapted for various sized pulleys. In the same list are shown engravings and information regarding their patent "Kilindo" non-rotating wire ropes.

ERNST SCHIESS, Düsseldorf, Germany.—General catalogue of machine tools. Part I.: Lathes. The types include self-acting and surfacing, turning and boring, break and roll lathes, axle, gun, and projectile lathes. Part II. is devoted to planing, shaping, and slotting machines. Part III., drilling, boring, and milling machines. Part IV., punching, shearing, bending, and straightening machines and angle iron dressers. The sole agent for these tools in England is Mr. W. Stamm, College-hill, Cannon-street, London.

PHŒNIX ELECTRIC HEATING COMPANY, Limited, 3, Holborn-place, W.C.—The apparatus included in this catalogue includes ovens, steamers, grillers, hot plates, furnaces, baths, urns, radiators, and many other articles for domestic use. The consumption of current in watts is stated against each article, and the customer who does not understand electrical terms is informed how to calculate the consumption, and hence the cost of using electrical apparatus.

COMBINATION METALLIC PACKING COMPANY, Limited, Gateshead-on-Tyne.—This packing has been very favourably received. It is made of several types. D, D^1, D^2 types are of the floating kind, specially designed for vertical high-speed engines, marine, or other engines where soft packing is required. The male and female rings are enclosed in cases; these cases, being smaller in diameter than the stuffing-box, are free to move laterally with rod. This type has been fitted into battleships and merchant vessels, as well as in high-speed engines of all classes. This type is fitted into a closed stuffing-box with a series of springs. A new form of metal joint is also being placed on the market by this firm.

SIEBE, GORMAN AND CO., Limited, Westminster Bridge-road, S.E.—"Oxylithe" first-aid equipment, for producing oxygen at a moment's notice, forms the subject of this pamphlet. "Epurite," a compound for producing oxygen, is described in another pamphlet. "Epurite" is a substance containing oxygen in a latent state in a form susceptible of easy liberation on contact with water. Oxygen set free by this agent is said to be chemically pure, every pound giving about 1¼ cubic feet of gas at an ordinary temperature of 59 deg. Fah. to 68 deg. Fah. By reason of the facility with which it can be employed, the inventors claim that "Epurite" brings pure oxygen within the reach of all industries at a lower figure than that of the more or less impure oxygen sold in tubes or tanks.

TAYLOR AND HUBBARD, Kent-street Works, Leicester.—A neat little book, containing a description with illustrations of a "controlled draught" furnace for steam boilers has been sent us. This furnace is not made or sold to be used for forcing the draught, but only to supply exactly the right amount of air to burn the necessary coal. The fire-bars are of special shape and construction, and the air spaces are designed specially to suit the kind of coal which will be used. The air supply is driven under the bars into the enclosed space by the two blower tubes. Air is also admitted at the back of the bridge to consume the smoke. The amount of this air is regulated by easily worked valves, which, at the same time that they admit air to the bridge, automatically reduce the air supply below the bars.

SOME NOTES ON COLLOIDS.*

PROFESSOR LOTTERMOSER has kindly furnished the following notes on colloids in order that the reader may better comprehend recent developments in incandescent electric lighting, and particularly the discovery of Kuzel, which have formed the subject of articles in the last three issues of THE ENGINEER.

In the phenomenon of solution it is established that the dissolved substance endeavours uniformly to fill up the entire volume of solvent—that is, it disperses itself. It accordingly exercises a pressure, by virtue of which it distributes itself in the solvent contrary to the action of gravity, and henceforth the dissolved substance behaves like a gas, which also uniformly fills all available space, although the velocity of diffusion of gases is incomparably greater than that of a dissolved substance. It is possible to apply for the dissolved substance the laws for the relation of gases, the discovery of which is mainly the work of Van't Hoff. We know dissolved substances, however, which possess only a very small, often vanishingly small, property of diffusion, in which case the laws of gases—perhaps just perceptible—have lost their validity. Graham was the first to establish this difference and study it more closely. He designated the substances of the first class with the name "crystalloids," since upon evaporation of the solvent they remain behind in crystalline form, whilst he called the substances with very small property of diffusion "colloids," since in gelatine he found a typical example of this class of bodies. The substances of the latter class remain after the removal of the solvent as an amorphous, not as a crystalline residue, and, therefore, one is wont to identify the conception colloidal with the idea amorphous. It must, however, be added that no sharp line can be drawn between the two classes of substances, since any number of transition forms are known.

According to the laws of solution, it is possible from the efforts to diffuse exercised by the dissolved substance, namely, its osmotic pressure, to calculate its molecular weight. In this way a very large molecular weight was found for the colloids, often up to a magnitude of 10^4, and still greater. In such cases, however, one is bound to consider, not single molecules, but molecular mixtures, always, of course, granted that the laws of solution are recognised as valid for these substances. If that is not done no other explanation remains but to exclude the idea of solution altogether and to introduce and accept a new idea, that of "Hydrosols." This Graham did, considering that the colloid was contained in the solvent uniformly distributed in an exceedingly finely divided state. Here arises, however, the new question, whether it is possible to observe these particles. This question can be considered solved and answered in the affirmative. It is, indeed, not possible even with great enlargement in the microscope to recognise any unhomogeneity of the hydrosol, but another optical method can be applied, the so-called Tyndall method. If a beam of light concentrated through a lens is allowed to enter a fluid, and is observed at right angles to the path of the rays, then the beam of light is only imperceptible if the fluid is homogeneous—*i.e.*, if nothing is present which turns aside the rays. Most solutions are of this character—are optically "empty." In the case of the hydrosols, however, the path of the rays is immediately rendered visible by means of a more or less illuminated bundle of rays, a proof that small particles are present, which reflect or divert a portion of the rays—in other words, make them perceptible to our eyes situated at right angles to the main path of the rays. Dust, for instance, makes itself visible in the fluid as illuminated particles, but these particles of dust are still millions of times larger than the particles of a hydrosol; the latter, therefore, cannot be observed by the naked eye as single individuals. If, however, in addition to the Tyndall experiment, the eyes are armed with the microscope—the transformation of this idea from theory to reality is the work of Zsigmandy and Siedentopf—single particles are, indeed, perceptible; their form cannot be freely observed, but diffraction images of them are received. The metallic hydrosols, which interest us most at present, have been especially examined in this way by the ultramicroscope, as the instrument constructed by the above-named scientists was called. They can be recognised in most cases as particles in active movement, and show an exceedingly brilliant image. It has thus been possible to define the size of the particles, which in brightest sunlight can be recognised up to a linear dimension of $5\mu\mu$ ($1\mu\mu = 0{\cdot}000001$ mm.). But here again, as it is well known that sudden transitions do not exist in nature, it is possible to arrive at particles, whose dimensions lie below this limit, which, therefore, can no longer be recognised in the ultramicroscope as single individuals, but only give a uniform faintly illuminated field of view, *i.e.*, they have become amicroscopic.

On the other hand, solutions are also known, which are not optically empty, which show the Tyndall phenomenon, a proof that we, as I have already pointed out, cannot draw a sharp line between hydrosols and true solutions. But it is also not possible to separate hydrosols sharply from liquids containing purely mechanical particles in suspension, the particles being visible under the microscope. These liquids, containing, say, clay or ultramarine in suspension, certainly possess no longer the properties of solutions; they show no diffusion phenomena; but it is also possible so to enlarge the particles of a hydrosol step by step that we come to dimensions which are to be observed by means of the microscope, and this hydrosol has then completely lost the properties of solutions.

After the above one cannot be surprised that suspensions and hydrosols have many properties in common. If an electric current is conducted through either a suspension or a hydrosol, although they experience a very great resistance, nevertheless the small particles are displaced; they stand, therefore, electrically opposite to the solution, carry a charge, and the direction of the displacement depends in general upon the chemical nature of these particles. Hence it is also natural that the direction can be altered by means of arbitrarily added substances, and in this way electrolytes exercise a particularly strong action.

Under electrolytes we understand, according to the well-known theory of electrical dissociation of Arrheius, substances which in solution promote the conduction of the electric current and are decomposed into electrically-charged "ions." These ions give up their charges to the electrodes, where the electric current enters and leaves the solution, and become unelectrified. The positively charged ions are called "kations;" they wander to the kathode, the negative electrode; the negatively charged ions are the "anions," and they move to the anode, the positive electrode. The above-mentioned promotion of the wandering direction of the particles produced by electrolytes is mostly caused in very small concentration; but we shall not here go closer into the laws. In somewhat greater concentration these electrolytes exercise such an action on suspensions and hydrosols, that the small particles coalesce into greater complexes, and now, because unelectric, are precipitated or coagulated, so that the hydrosol becomes a "hydrogel." Here, too, quite regular laws can be found in regard to the gelatinising action of the electrolyte, which stand in closest connection to the relations found for the promotion of the wandering tendency. Here, however, attention will only be devoted to one rule of importance in the understanding of this electrolytic action, that the action of an electrolyte, besides that which brings about the coalescence of the two ions—namely, the charged ion opposed to the particles—exercises a specific precipitating influence, increasing considerably with the atomicity of this ion; whilst with the equally charged ion the precipitation decreases, or is arrested altogether. There is, therefore, a specific protective action. Although the influence of electrolytes on hydrosols, and their connection with the wandering direction of the hydrosol particles, is of the greatest importance in the researches into the nature of hydrosols, nevertheless we shall not here go closer into these phenomena, nor into the theory of hydrosols, especially as we are still far removed from a thorough knowledge of this difficult field.

As we can by pure mechanical pulverisation of matter only attain to the stage of suspension, to produce a finer division of matter, such as we have in hydrosols, we must make use of energy of another kind. For this purpose chemical and electrical energy offer us substantial aid. By means of both it is possible to obtain metallic hydrosols. In the preparation of which by chemical means care must, of course, be taken that all such electrolytes which exercise a strong precipitating action—for instance, such as possess a high molecular charged ion opposed to the hydrosol—are carefully excluded, and that the reduction, for the chemical reaction in this case is always of that nature, proceeds in dilute solution or in the presence of such electrolytes as produce a reversible gelatinous substance, that is to say, such a gel as, on the addition of the solvent, is immediately converted again into the hydrosol. In this latter way the hydrosol of silver has been prepared by Carey Lea, in very dilute solution the hydrosol of gold by Zsigmundy, and by the author several hydrosols of the platinum metals. Also a reduction method used by Paal, the author, and others lead to the production of the colloidal metal. This method rests upon the fact that most organic colloids prevent the precipitation of the metallic hydrosol in concentrated electrolytic solution against the electrolytic influence. The product, however, always contains a large proportion of these added foreign colloids.

The second method for the preparations of metallic hydrosols is the electric arc. Bredig found that by the pulverisation of the cathode in the electric arc under water it was possible to produce a whole series of metals, namely, the noble metals, as hydrosols. Later, Billitzer applied the same method, and lately Svedberg has succeeded in pulverising many metals to sols in this way. Of course, such metals as decompose water cannot be converted into hydrosols, but into sols in various organic liquids, as so-called "organosols." Finally, it is also possible, by the cold pulverisation of the cathode depending upon the electrolytic method above mentioned, to convert not only metallic, but also non-metallic elements into hydrosols. Although now, as already stated, the particles wander in the electric current, the hydrosols show, especially those of the metals, only an exceedingly small conductivity, which is probably to be attributed to the ions present at the same time, which may certainly be a phenomenon essential to the hydrosol state. By whatever method, whether by evaporation or electrolytic influence, the precipitated gel conducts the electric current either not at all or, at least, very badly. Barus and Schneider found this to be the case with silver, and no wonder, since it consists always of small disconnected particles, incomparably greater than those of the hydrosol. Küzel has applied these discoveries to the preparation of his electric lamp filaments. The filaments only begin to conduct continuously after being strongly heated, in order to bring about the transition from the colloidal into the crystalline metallic condition, and so produce a uniform metallic conductor of exceedingly small diameter.

* Appendix to the article on the "New Incandescent Electric Lamps."

THE WORKS OF THE WESTERN ELECTRIC COMPANY OF AMERICA.

THE main manufacturing plant and offices of the Western Electric Company are in the Chicago industrial suburb of Hawthorne, and the company has a very varied line of manufactures; it includes dynamos and motors of all sizes, electrical machinery in general, telephones, electric light apparatus, electric cables, and other specialities. The plant occupies a site of 110 acres, and the buildings cover about 25 acres. The buildings are of steel skeleton construction, with brick walls, concrete floors, and tile roofs. The plant is served by sidings from railway lines, and has a complete system of industrial railways. Fig. 1 is a plan of the entire plant.

Beginning with the foundry, this is a long building, 400ft. by 176ft., and about 75ft. high to the roof. It is divided into three bays, the centre one of which is 75ft. wide, and served by two 30-ton electric travelling cranes. One of the side bays is 70ft. wide, and has a low roof; this is used exclusively for bench work. The other side bay is 30ft. wide, and is divided into sections containing the cupolas, storage bins, and core ovens. Fig. 8, page 656, is an exterior view of the foundry.

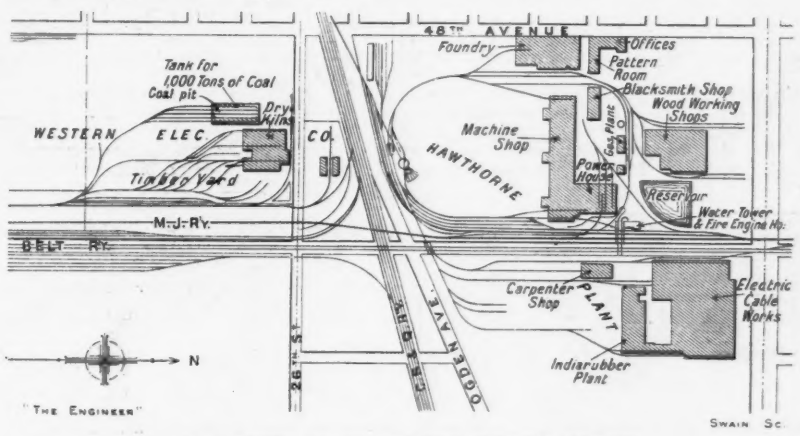


Fig. 1—WORKS OF THE WESTERN ELECTRIC COMPANY

The machine shop, lying at right angles to the foundry, is 860ft. long and 150ft. wide, and is of the same type of construction as the foundry, except that the roof is of iron and tarred-felt construction. There are three bays. The centre one, 76ft. wide, is devoted to the manufacture of generators and motors. The north bay, 48ft. wide, contains such machine tools as are required in the manufacture of small types of machines. In this bay is also the testing department. The south bay has two floors, the upper one being devoted to the manufacture of small field coils and the winding of small armatures. It also contains the small detail and finishing departments. The lower floor contains the commutator and large detail departments, stock-rooms and general shop offices, including that of the shipping department. The lighting is obtained from overhead skylights and side windows. Over the main bay are two 30-ton and over the north bay six 20-ton travelling cranes. Exterior and interior views of this main building are shown in Fig. 2, page 646, and Fig. 9, page 656.

The cable making and india-rubber shops form a separate group of buildings. Entering the cable shops from the south is a railway track connecting with the receiving department—which covers 15,000 square feet—at which the raw material is received. Adjacent to this are the insulating and wire twisting departments, covering 22,500 square feet, from which the material passes into the cable twisting room, covering the same area. From here the cable passes into ovens, covering an area of 10,000 square feet, and is finally delivered through small openings in the wall to the press-room, where the lead sheath is applied. This room is 360ft. by 100ft. At the south end is a storage pit for lead, in which, under normal conditions, is stored about 2000 tons of lead.

Immediately adjoining this section is a room 100ft. by 50ft., in which is a battery of six impregnating tanks, used in the insulating of power cable, made in another adjoining room, covering 15,000 square feet. In addition to these departments, there are the testing and shipping sections, covering an area 440ft. by 50ft. There are in process of construction, and almost completed, buildings

which will more than double the capacity of the present cable works.

The rubber plant forms an annex or wing to the cable plant, and is immediately south, being separated from it by an open space or court 200ft. square, which is used for the storage of cable reels. It has the same railway

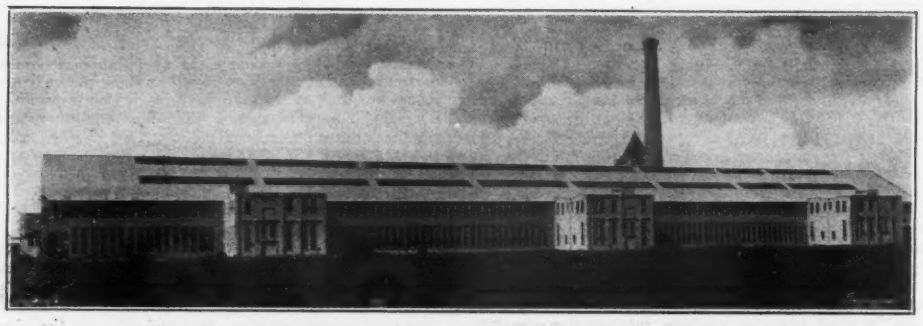


Fig. 2—MACHINE SHOP OF THE WESTERN ELECTRIC COMPANY

connection as the cable plant, and is divided into four sections, covering an area of 40,000 square feet: (1) The compound mixing; (2) grinding and vulcanising; (3) sawing and finishing; and (4) the shipping rooms. A portion of this plant is two storeys high, the second floor being devoted to the process of drying crude rubber.

The power plant occupies a building of its own. The boiler-room has an area of 20,700 square feet, and has two brick chimneys, each 12ft. inside diameter, and 250ft. in height above the boiler-room floor. Provision has been made for four batteries of boilers, with four boilers to each battery, each chimney serving two batteries. At present there have been installed eight boilers of the Aultman and Taylor Company's make, each with a heating surface of 5080 square feet, and operating under a steam pressure of 150 lb. They have chain-grate stokers. Each set of four boilers is provided with a Green's fuel economiser of sixty-eight sections, twelve tubes wide. The water tubes of the boilers are cleaned by means of an hydraulic cleaner supplied with water from a duplex pump.

The main railway tracks dividing the company's property afford an easy means of handling the coal, as they are at such a height that the coal wagons may be shunted by means of an elevated spur track into the storage bins above the boiler-room. These bins are of 1000 tons

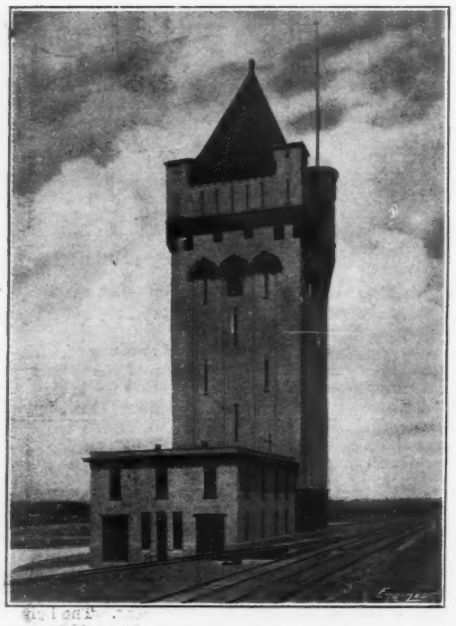


Fig. 3—WATER TOWER

capacity, and are so designed that the coal may be discharged through spouts into a weighing hopper for each division of boilers. This hopper is mounted on a line of rails, so that it can take the coal from any part of the bin and deliver it to any one of the stokers. The ashes are discharged from the end of each chain-grate stoker into a bin of 1½ tons capacity situated below the boiler. From these bins the ashes may be delivered into railway trucks on a depressed line of rails and taken to various places about the site where filling may be required.

The continual uncertainty of the coal supply, due to strikes and other conditions beyond the control of the manufacturer, has led to a careful consideration of the problem of coal storage, and after carefully investigating the question, the company decided to adopt the plan of storing coal under water. The storage bins, or tanks—one of 4000 tons and the other of 10,000 tons capacity—both below the normal ground level, have been constructed; into these coal may be dumped from railway wagons, and taken out by means of a locomotive crane fitted with a grab bucket. By keeping the bins flooded, the company expects to reduce the losses in the heating value of the coal to approximately 2 per cent. after six to twelve months' storage. By this system of storage there is provided sufficient coal to operate the plant under normal winter conditions for four months.

A Cochrane open feed-water heater of 8000 horse-power capacity, and two 14in. and 10in. by 15in. Worthington duplex vertical boiler-feed pumps are installed in the boiler-room. The engine-room and condenser pit contain a power plant having a capacity of 3000 kilowatts for continuous service, and 4500 kilowatts for two hours service. There are four units, one each of 300, 500, 1000, and 1200 kilowatts capacity.

The largest generator is driven by a vertical cross-compound Rice and Sargent engine; the diameters of the cylinders are 32in. and 62in., the stroke is 48in., and the piston speed 800ft. a minute, the engine making 100

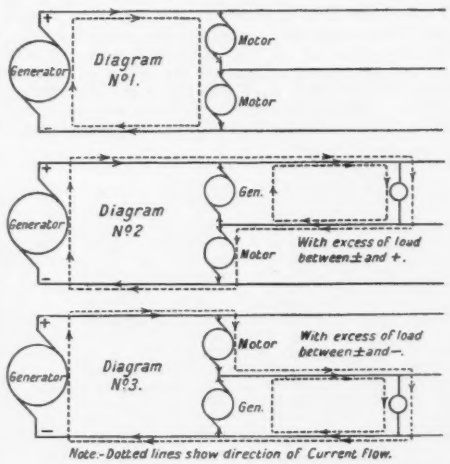


Fig. 4—DIAGRAM OF ELECTRIC CONNECTIONS

revolutions per minute. The 300 and 500-kilowatt generators are driven by horizontal cross-compound engines, and the 1000-kilowatt generator is driven by a vertical cross-compound engine made by the Filer and Stowell Company. Fig. 7 is a view of one of the vertical engines with its generator.

There are three Wheeler surface condensers, two with 3200 square feet and one with 4500 square feet of cooling surface, also three Blake duplex single-acting air pumps.

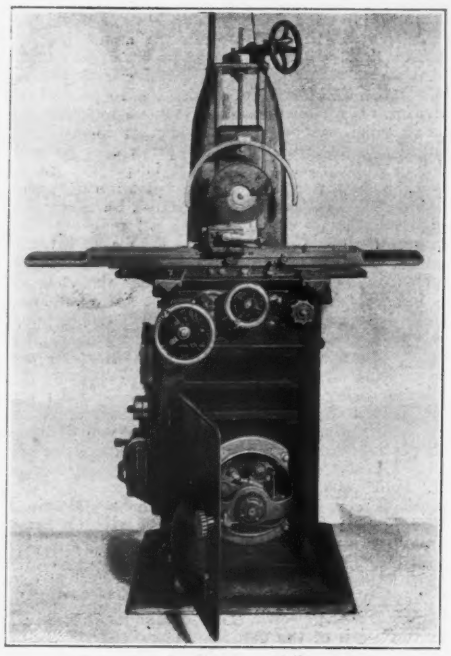


Fig. 5—ELECTRIC GRINDING MACHINE

The condensing water is obtained from a reservoir of 5,000,000 gallons capacity, which is primarily for fire protection purposes. Two 10in. and one 12in. motor-driven centrifugal pumps are used for circulating the water, and operate under a load of 37 horse-power and 45 horse-power respectively. These pumps are called upon to furnish only sufficient power to overcome the friction of the pipes, as the condensers are below the level of the water in the reservoir, the suction and discharge pipes being submerged. A 20-ton electric travelling crane with a five-ton auxiliary hoist is arranged over the engines, and a 15-ton crane over the condenser pit.

In addition to the reservoir previously referred to, a water tower of artistic design—Fig. 3—has been provided, in which there are six steel tanks having a total capacity of 213,000 gallons; these are connected with the automatic sprinkler system for fire protection, the bottom of the lowest tank being 38ft. above the highest sprinkler in the plant. These tanks can also supply the fire hydrants throughout the works. The water tower contains other tanks with water for sanitary purposes. City water is used in both the reservoir and the tower. Drinking water is obtained from a pipe or driven well 300ft. deep, supplying 40 gallons a minute; this is pumped by a direct-acting deep-well pump, and is delivered in pipes to all departments. The water has a temperature of about 56 deg. Fah.

Compressed air is used for working pneumatic tools, blowing out cables and electric machinery, and operating foundry moulding machines. The entire plant is supplied with air at 90 lb. pressure by a 20in. and 12in. by 18in. two-stage air compressor direct driven by a compound engine with cylinders 12in. by 19in. by 18in. stroke, and fitted with a Myer release gear. This compressor unit is placed in the condenser pit. Uncarburetted water gas for use in the heating and baking ovens and

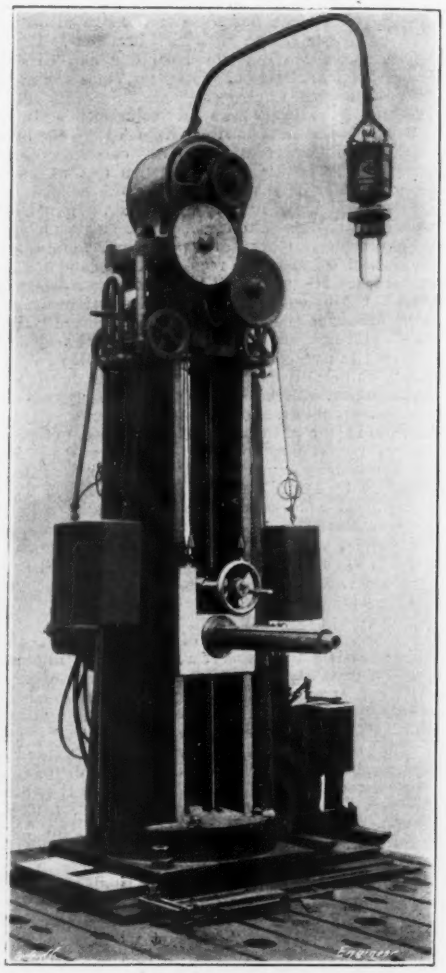


Fig. 6—ELECTRIC DRILLING AND BORING MACHINE

annealing furnaces about the works is furnished by two generators, each with a capacity of 25,000 cubic feet an hour. The gas is stored in a holder of 100,000 cubic feet capacity, and has a heating value of approximately 300 B.Th.U. It is made from a good grade of furnace coke, and costs, exclusive of fixed charges, such an amount as to compete favourably with 12,000 B.Th.U. coal at 11s. 8d. per ton. It has approximately 50 per cent. of the heating value of, and costs 50 per cent. less than, city gas. A new holder, of 200,000 cubic feet capacity, is now being constructed, and will enable one gas generator to be run during the entire twenty-four hours, with pronounced economy over present conditions, which require both generators to work at certain times of the day.

All buildings are heated by direct radiation, except the foundry and machine shops. The foundry is equipped with a hot-air system, while the machine shop has a combined direct-radiation and hot-air system. The heating coils are supplied with steam under the Warren-Webster system, with two Blake Simplex vacuum pumps. In the winter time one or more engines are operated non-condensing, the steam circulating under slightly more than atmospheric pressure. The efficiency of the above arrangement is apparent when it is explained that during last winter no steam was required for heating other than that furnished by the exhaust of the engine.

A destructor, having an area of approximately 1600 square feet, deals with the shavings and chips from the carpenter shops. It contains a boiler and "Dutch oven," specially designed for the purpose, and provision has been

made for doubling the capacity by building a second unit when it is required. The carpenter shops are equipped with an exhaust system from the various machines, and are provided with an edging-hog, which grinds the larger waste wood into shavings small enough to pass through the exhaust pipes into the destructor furnace. The boiler is directly connected to the main steam line, and under normal conditions about 400 gallons of water are evaporated per day, to a pressure of 160 lb. per square inch, thus augmenting the general steam supply.

The entire plant is electrically driven, individual motors being employed except in a few cases. The machine shop and cable works contain many variable-speed motors, which are operated from a three-wire system, with a compensator or voltage-balancer in each of the buildings so equipped. This compensator is of sufficient capacity to carry the unbalanced load resulting from the variable-speed motors, and the arrangement is shown in the diagrams in Fig. 4. The voltage-balancer consists of two 115-volt machines connected in series directly across the mains, with the neutral connected between them. The machines are compound wound, the series fields being connected in the neutral wire. In diagram No. 1 the load is supposed to be equal on both sides of the neutral wire, in which case both machines are running as motors, the current passing in the direction indicated by the dotted line. Under these conditions the compensator is not affecting the circuit. In diagram No. 2 the excess of load is shown between the positive and neutral wire, in which case the unit of the compensator connected upon this side of the neutral is driven as a generator by its twin. The current in the generator is of such a value that, when added to the motor current, it will be sufficient to restore the voltage balance. The currents will then be flowing in the direction indicated by the two dotted lines. In diagram No. 3 the reverse conditions exist.

Particulars of some of the tool and machinery equipment will be of interest. The forge shop has electrically-driven cold saws, shears, bulldozers, blowers for forges, and two cutting-off machines. In the machine shop is a Bliss press driven by a 50 horse-power motor running at 1000 revolutions per minute; the motor is mounted on top of the press frame and geared directly to the machine through an internal gear on the fly-wheel, which meshes with a pinion on the motor. A Ferracute punch press for slotting large armature discs is driven by a protected type variable-speed motor, of ¾ horse-power, belted to the fly-wheel of the machine. There are also several shears for sheet iron work, with motors of 2 horse-power, at 1850 revolutions. The motor is mounted in an inverted position on the under side of the machine table, and is direct geared through a raw hide back gear to the main driving shaft of the machine. There is a number of grinding machines, and a Springfield surface grinder is driven by a 2 horse-power motor running at 850 revolutions; the motor has a pulley at each end of the shaft, and both of these pulleys are belted to the spindle of the grinding wheel. The motor is mounted on the grinder head, and travels with it across the work. On about the same level with the main motor, but behind the housings, is an auxiliary motor mounted on a bracket, and direct geared through an internal gear to the shaft which carries the open and crossed belts for the reversible bed travel of the machine. A Pratt and Whitney surface grinder, having a 6in. grinding wheel, is directly coupled by a flexible coupling to a motor of ½ horse-power running at 2600 revolutions. Fig. 5 shows one of the numerous electric grinders used in the foundry, machine shop, and forge shop, all of which are motor driven. Mounted inside of the pedestal is a Brown and Sharpe surface grinder with a belt passing around it to a set of counter-weighted pulleys on the grinder spindle. In this way the grinder may be raised or lowered to suit the height of the work, while maintaining the proper belt tension for all positions.

Among the larger machine tools in the machine shop is a Dietrich and Harvey open-sided planer, 10ft. by 24ft., driven by a 40 horse-power open-type motor running at 950 revolutions. The motor is mounted on a bracket on the housing, high enough to be out of the way, and is belted to a countershaft on the machine. There is also a 3 horse-power motor on top of the housings which serves to raise and lower the crosshead. A Niles extension boring mill is driven by spur gearing from a 10 horse-power motor placed below the floor; a 3 horse-power auxiliary motor is mounted on the rear of the bed-plate, and is geared to the traversing screw for raising and lowering the crossheads and for traversing the housings. Near this machine is a row of eight Gisholt turret lathes; each is driven by a variable-speed motor, and has on the rear of the bed, below the headstock, a small auxiliary motor for traversing the turret. Among the portable machines is a large Newton boring and drilling machine, shown in Fig. 6. It is entirely self-contained, and has an arc lamp as well as the motors for power. There are two heavy stirrups, one on each side of the frame, near the top, so that it may be easily picked up and carried about by the travelling cranes.

In the insulating department of the cable works are eighty insulating machines, each having five heads operating simultaneously to insulate five wires. The arrangement is such that two machines are driven by one 3½ horse-power variable-speed motor operated by a specially designed controller. After the wires are insulated they are twisted together in pairs by the twisting machines. These are operated by encased motors of 1 horse-power, running at 1300 revolutions, and connected to the machines through spiral gears. On the end of each machine frame, above the motor, is a solenoid self-starter which is operated from two push buttons, one for starting and the other for stopping the motor. In the room adjoining that containing the smaller twisters are the cable-twisting machines. The largest one of these machines will carry nearly 600 reals of twisted pairs of wires.

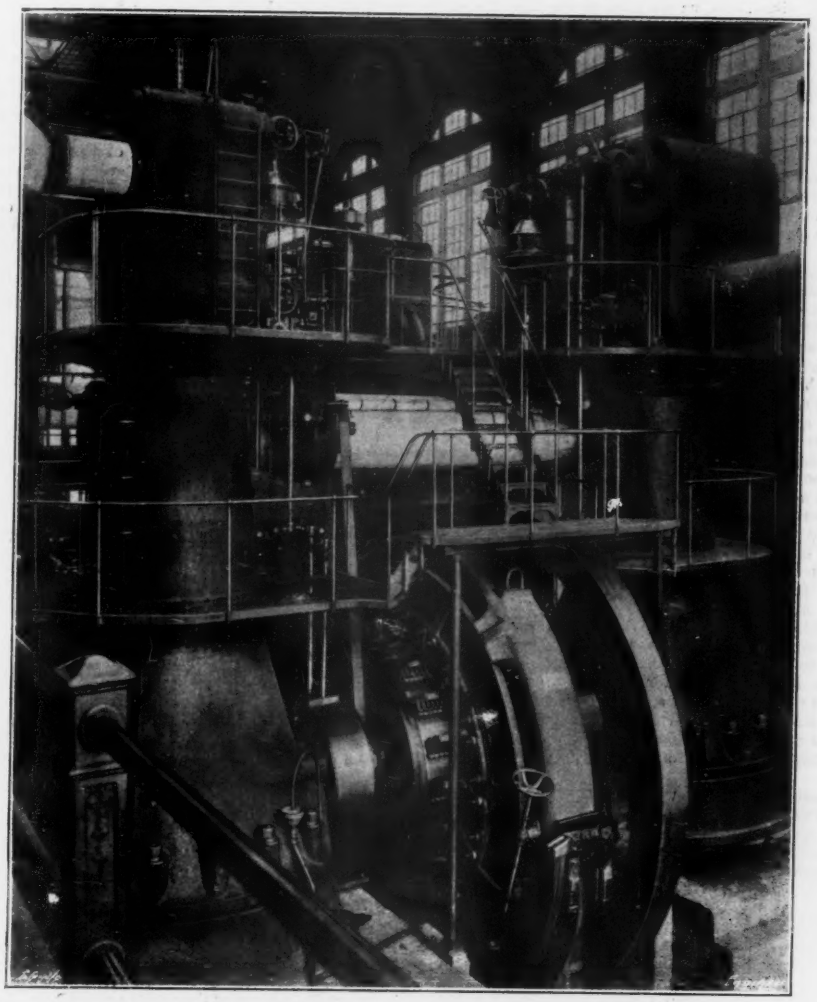


Fig. 7—VERTICAL ENGINE AND GENERATOR

In the lead-covering department there are several 30 horse-power slow-speed motors, each direct connected to the crank shaft of a high-pressure pump operating a hydraulic press used in the process of covering the cables with the lead casing.

The lead-covered cable as it is delivered by the presses is wound upon large wooden reels for shipment. Each reel is driven by the contact due to its own weight upon a pair of motor-driven parallel rollers whose upper surfaces are on a level with the floor. The motor which drives these rollers is below the floor and operates them through a worm gear. It is controlled by a special mechanism operated by push buttons held by the operator while directing the cable. The special mechanism consists primarily of a reversible motor of ½ horse-power, the extended armature shaft of which is threaded, and drives a controller contact over the segments of a controller.

In the rubber plant are several examples of large machines electrically driven. The department where the crude rubber is washed has a number of collenders, each geared to a 20 horse-power motor at 670 revolutions; also several dust removers geared to a shaft under the floor, which is connected through a spur gear to a 200 horse-power motor, placed in a pit of sufficient depth to permit this connection by a single reduction. In an adjoining room a 200 horse-power motor, fixed below the floor, drives through positive gearing five rubber grinders, each of which may be thrown in or out of service by means of a large clutch. A smaller grinder is individually driven by a 50 horse-power motor—600 revolutions—through a raw-hide pinion and double reduction. A double tin-foil mill is directly geared through a double reduction of spur gears to a 200 horse-power motor running at 450 revolutions. The large gear is about 10ft. in diameter, with a 12in. width of face.

As a rule, the different departments have separate one-storey buildings, each far enough removed from its neighbours to eliminate the danger of fire spreading. Large areas are divided by heavy fire walls, with double tin-clad fire doors at the openings. The walls are of brick, with wire-glass in the windows at exposed points, and the floors are of concrete, or concrete with wooden surface. The roofs are tile on structural steel framework. With the exception of three buildings, the property is protected throughout by automatic sprinklers. The three exceptions are the foundry, the forge shop, and the main body of the machine shop, in which there is absolutely no combustible material.

The various buildings are connected with the power-house by a system of well-lighted and ventilated tunnels for the various services, in which are arranged the telephone, lighting and power cables, and the pipes for the drinking, city and house water, compressed air, live and exhaust steam, vacuum and trap returns, roof drains, and hydraulic lifts. These tunnels have a uniform height of 7ft., and vary from 4ft. to 10ft. in width. Connecting with the tunnel leading to the machine shop is a system of concrete trenches surrounding the iron plates of the testing floor. Within these trenches are cables leading into junction points at which are available for testing purposes all voltages from 30 to 600 volts, both direct current and alternating current of 25 and 60 cycles. The yard and building illumination consists of arc lamps, two in series on 220 volts, and incandescent lamps for local lighting.

The organisation of the works includes an engineering inspection division, which is an important department with numerous duties, particulars of which have recently been given by one of the engineers. These duties may be classed under five heads—namely, (1) inspection and testing of experimental models, and suggesting improvements in these; (2) inspection of shop methods; (3) inspection and testing of finished apparatus; (4) inspection of installations made by the company; (5) investigation of complaints. For many years it was the practice to begin the manufacture of new designs without paying particular attention as to whether the design was as good as it might be in regard to economy of material, ease of adjustment or repairs, and reliability.

LITERATURE.

The Theory of the Steam Turbine: A Treatise on the Principle of Construction of the Steam Turbine, with Historical Notes on its Development. By ALEXANDER JUDE. London: Charles Griffin and Co., Limited, Exeter-street, Strand.

THE scope of this work is mainly theoretical, and the descriptive matter is principally introduced by way of example. The fundamental principles on which the design of the steam turbine is based are considered at some length, and the effects of leakage, steam friction—viscosity—and other causes of loss are very fully treated, both theoretically and practically, by the consideration of experimental results.

Chapter I. is entitled "Fundamental," and begins by reciting the usual theorems dealing with the pressure produced and the work done by a jet of fluid impinging on plane and curved surfaces. There is a confusing misprint on page 3, where v_2, defined as the velocity of the jet relative to the plane surface, is substituted for A D, which is the absolute velocity of the fluid stream after impinging. The author then defines a turbine as follows:—"A turbine is a prime mover in which gradual changes in the momentum of a fluid are utilised to produce rotation of the mobile members." He also defines "open" and "closed" buckets or vanes, and finally tries to clear away the confusion which now exists between so-called reaction and impulse turbines; in our estimation, however, he has only partially succeeded. It would be a great advantage if some authoritative pronouncement could be made on the subject.

A few historical notes are given in Chapter II., jus

sufficient to give examples of ancient turbines embodying the principles of the various types of modern turbines. It is interesting to note that Wilson's radial flow compound impulse turbine, patented in 1848, is based on the principle of partial admission, an arrangement which appears to have been re-patented by Parsons in 1901, and is also that on which the Rateau turbine depends.

The velocity of efflux of steam is considered in Chapter III., and expressions for calculating the velocity for a given heat drop under various conditions are first investigated analytically, and further explanations are given graphically by means of the entropy-temperature method. The chapter concludes with a description forming a good digest of the experiments made by Stodola, De Laval, and Rosenhain on the efflux of steam from nozzles. A valuable and interesting set of experiments made by the author with an apparatus for observing oscillations of pressure within turbine vane passages are given at some length, and will well repay study.

In the next chapter a classification of the various types of turbines is attempted, and although it is one of the most rational and complete classifications which has come under our notice, it is not entirely satisfactory. Some interesting photographic reproductions of the erosion produced by wet steam having a velocity of about 2600ft. per second on such metals as rolled copper, rolled Delta metal, cast copper, and gun-metal are given. These are only examples of many experiments made by the author, and amongst the conclusions he has come to we find the following:—"The usual alloy for Parsons vanes (63 Cu + 37 Zn) is quite unsuitable for superheated steam or for high velocities, being readily pitted and eroded; cupronickel (80 Cu + 20 Ni) is an excellent material, and has the advantage of being non-corrodible." Many of the various kinds of turbines now being manufactured are described in Chapter V., and the advantages and disadvantages of each are impartially stated. As might be expected, the Parsons and the Curtis turbine are more fully discussed than any others. Reference is also made to some designs of turbines which are not manufactured.

Chapter VI. is entitled "The Efficiency of Compound Turbines," and begins with the usual velocity diagram. The author defines the term "diagram efficiency" as the ratio of the energy absorbed in doing useful work to the energy supplied to any one or a series of moving vanes. He uses the same expression in Chapter I., but in that chapter the vane losses—shock, spilling, and friction—are considered to be nil. In Chapter VI., however, and in the sequel, these losses are included. The term "diagram efficiency" appears to be new, and has merit if confined to the definition of Chapter I.—that is, with no vane losses; it is then purely geometrical. The word "diagram" appears out of place when losses due to shock, &c., are included. At the same time it must be conceded that the author modifies the usual velocity diagram so as to take account of the vane losses, which he evaluates from certain experiments made by Rateau and others, so that in reality he does obtain geometrically the ratio of energy absorbed in doing useful work to the energy supplied to any one or a series of moving vanes. He works out several numerical examples which show very clearly the effect on the diagram efficiency of varying the inlet and outlet angles of the vanes and also the ratio between the steam and the vane velocities. This chapter deals only with turbines of the Rateau type, and concludes with the description of a method for calculating the number of stages and for obtaining the area through the guide blades, and some interesting numerical examples are given as to the amount of leakage likely to occur in this type of turbine.

Chapter VII. deals with the true path or trajectory of the steam, and some important points in connection with the shape of the moving blades are evolved. Chapters VIII. and IX. are practically a repetition of Chapter VI., dealing with other types of turbines, such as the Curtis and the Parsons. It is interesting to note that the "diagram efficiency" of the Parsons turbine is better than that of any other type, but, the author points out that, "leakage from stage to stage over the vane ends, and especially past dummy pistons, is, however, a serious item, and appears completely to nullify any semi-theoretical advantage, as above discussed."

A few of the methods of making and fitting turbine blades that have been proposed and patented are then described. Many of those given, however, are not in actual use, and it should be noted that it is stated that the Willans turbine blading is being built in accordance with Fullagar's patent, No. 21,932 of 1903, whereas in reality, as regards the rooting of the blades, Sankey's patent, No. 6055, of 1904, is adopted in this turbine.

Chapter XI., although short, is important, and gives a good abstract of the few published experiments that have, up to the present, been made to determine the disc and vane friction. The pumping action of discs when rotating above a certain critical speed is considered. It would appear that this critical speed is that at which the fluid is thrown off the edge of the disc, so that the action is like that of a centrifugal pump, and it is shown that this critical speed is well below turbine speeds. This chapter makes it very apparent how limited is our knowledge on the subject, and what a large field for experimental study is open in this direction. An interesting numerical example is given, in order to get some idea of the relative amounts of the disc and the vane resistances, and it is shown that the latter is considerably the smaller. It is also pointed out that, in the case of the Rateau turbine, these resistances may become prohibitive, if due care is not exercised in selecting the various dimensions.

Chapter XII. deals with the specific heat of superheated steam, and refers to the latest published experiments on the subject. There is a good digest of Professor R. H. Smith's reduction of Lorenz's experiments, as given in THE ENGINEER of July 8th, 1904.

The methods of calculating the strength of rotating discs are more than usually fully treated in Chapter XIII., but it is feared that the mathematics will be found difficult to follow by many engineers. The author discusses with the methods usually employed for determining the dimensions of discs rotating at a high speed. The investigation will principally be of interest to those designing turbines of the De Laval type.

The governing of steam turbines is next treated, the theoretical consideration of the subject being based on the "Willans" law, and an ingenious method is elaborated for calculating the steam consumption at no load. Several numerical examples are worked out for various types of turbines, and the results are consistent with actual trials. There is some obscurity, however, in the description connected with Fig. 206; it would appear as if the total consumption per "indicated" horse-power was zero, which is not the case. Even in the case of the perfect, or Rankine, steam engine, the total steam consumption is not zero, unless the back pressure is also zero. The author comes to the conclusion that governing by periodical admission, in accordance with the method invented by Parsons, is of very little economical advantage, and that its only merit is to keep the governor valve from sticking. It has, however, the disadvantage of sometimes causing considerable difficulty in inducing turbo-alternators to run in parallel. The governing requirements for continuous-current dynamos and alternators respectively are very clearly given. It is a question on which there is a considerable amount of misunderstanding, and therefore a clear exposition is of value.

Chapter XV. deals with the steam consumption of turbines, and begins with the consideration of the effect of vacuum, and a comparison is made with reciprocating engines. The reasons why turbines derive more benefit from a high vacuum than a reciprocating engine are accurately given, and we are glad to see that the author measures the vacuum in the exhaust branch and not in the condenser; this is a matter of extreme importance, especially with high vacua, but, unfortunately, is frequently disregarded in reporting the results of economy tests. The effect of superheating is next considered, especially as regards the amount of superheat which is economically advantageous, and the conclusion is come to that a superheat of from 150 deg. Fah. to 200 deg. Fah. offers the best economy. Some practical suggestions are given as to the methods of fitting thermometers for measuring superheat, and it is stated that readings may easily be obtained too low by 60 deg. Fah. if such details are not attended to. Numerous experimental results with Parsons turbines are given, both in a tabular form and graphically, and these are used later in the chapter to determine the most economical vacuum, taking all items of expense into consideration. The results of the calculations are plotted, and it is shown that there is an improvement in economy up to 28in. of vacuum—in the exhaust branch—after which there is a loss of economy, which increases very rapidly. The investigation, however, is somewhat marred by assuming a load factor of 13 per cent., which is the load factor appropriate to the whole plant in a station. The investigation under consideration, however, deals rather with a single unit, and the load factor should, therefore, be taken considerably higher, say, 50 or 60 per cent. The author says that the thermodynamic efficiency is the "ratio of the work done per lb. of steam to the work available per lb. from complete adiabatic expansion." This definition is incorrect, as the ratio given is the "efficiency ratio," as defined by the Thermal Efficiency Committee of the Institution of Civil Engineers. The thermodynamic efficiency is, as is well known, the ratio of the heat utilised to the heat supplied.

There is a short chapter on the whirling of shafts, which in reality is mainly a *résumé* of Dr. Chree's memoir on the subject published in the "Proceedings" of the Physical Society. A numerical example is given in which the critical speed works out to 800 revolutions per minute.

The last chapter deals with the speeds of turbines both for land and marine purposes. There are three diagrams at the end of the book, by means of which various thermodynamic calculations in connection with turbines can be graphically solved. One of these is an entropy-temperature chart, dealing principally with superheated steam.

It is apparent from several remarks interspersed throughout the book that the author holds no brief for steam turbines, and in the preface he says: "The book will, at any rate, serve a useful purpose . . . if others are assisted to form a sound judgment of the steam turbine problem, unswayed by the omissions and exaggerations of advertisements or the enthusiasm of fashion."

We can fully recommend this work; it is certainly one of the best on steam turbines which has come under our notice.

Maschinenkunde für Chemiker. Von A. von THERING. 8vo., pp. 396, with 352 cuts and 7 plates. Leipzig: J. A. Barth. 1906. Price 14 marks.

THIS is the third volume of a new series which, under the general title of a "Handbook of Applied Physical Chemistry," is intended to cover a very wide range of subjects, as, according to the accompanying prospectus, it will extend to more than twenty volumes by eminent specialists, where matters such as calorimetry, the production and measurement of high temperatures of the electrolysis of solutions and molten electrolytes, the physics of glass manufacture, spectroscopy, distillation, firing, explosives, &c., will be treated at length, according to the latest physico-chemical developments. The present volume, as stated in the preface, is intended as a means of general information to chemists concerning the principal kinds of machinery employed in chemical works on the large scale, besides serving as a text-book for the course delivered by the author, who is one of the heads of the Imperial Patent-office at the University of Berlin. The text is divided into four parts, the first dealing with the fundamental principles of mechanics and thermodynamics, including the discussion of the thermal cycles in steam and gas engines, which are concisely treated, although possibly the mathematical requirements may be beyond the compass of the average chemist at present. The second part describes power producers under the heads of steam boilers and engines, gas engines, and water-power motors, giving good general ideas as to the different systems of modern motors, including superheated steam and steam turbines, and the newer forms of gas engines, together with descriptions of the use of the indicator and dynamometer, the discussion of indicator diagrams, and the methods of conducting boiler and engine trials, the hydraulic tests being more summarily treated. The third part, on working machines, includes lifting and carrying machinery, such as bucket elevators and conveyors, pumps, and other contrivances for lifting fluids, blowing engines, compressors and fans. Then follow crushing machines, including rock breakers, edge rolls, and disintegrators, and the subject is completed by mixing and separating machines, the latter including filter presses, centrifugals, and distilling arrangements. The final part, under the title of machines and apparatus for the production of heat and cold, includes under the first head a short and not very satisfactory notice of furnaces, followed by a more detailed account of crystallising and boiling down pans, driers, and single and multiple effect vacuum evaporators. The second and final chapter on the production of cold gives a good account of the physical principles involved in the condensation and liquefaction of gases, and their application to refrigerating uses and ice-making. This is accompanied by a series of plates illustrating two different refrigerating plants, which seem to realise what may be considered to be the principal function of such a book, namely, showing the method of applying the principles described, and the relative position and importance of the appliances required to realise them in practice. In other respects the book, though excellent as a whole, is decidedly uneven. After giving a large amount of space to the details of steam engines, including the later refinements in construction, and the use of indicators and dynamometers, we find it stated, on going to the section on water power, that the determination of the available water power in a large stream is a matter only to be undertaken by a hydraulic specialist—a very wise remark, which, however, would seem to apply to other parts of the volume, which go into details rather beyond the needs of the average chemist. For a modern book the omission of all mention of electro-motors is somewhat remarkable. The work is remarkably fully illustrated, mainly by the co-operation of manufacturers of the different specialities described in the volume.

SHORT NOTICES.

Electricity Meters. By Henry G. Salomon. London: Charles Griffin and Co., Limited.—The meters described in this book are divided into three main classes, viz., continuous current and tariff meters. They are arranged in eight chapters, corresponding to the following eight sub-divisions:—Continuous current quantity meters; continuous current energy motor meters, without iron in the field or armature; continuous current energy meters of different types; continuous current meters for special purposes, such as battery, switchboard, and tramcar meters; single-phase and polyphase induction meters; and tariff and prepayment meters. The general principles involved are explained in three separate chapters, and a special chapter is added in which the more important mechanical features of meter construction are pointed out, only the electrical details being given in the actual descriptions of the various types. Chapter X. describes the many tariff systems. There is the "flat rate system" with and without discounts, which gives no encouragement to the general use of current during the day, nor offers any inducement to the long-hour customer to continue his custom. The second system described is that known as "the Manchester," and was devised by Dr. John Hopkinson. In this system a fixed charge per quarter was originally adopted, but has now been modified. The "maximum demand" system was originated in Brighton by Mr. A. Wright. The principle consists in charging the consumer two prices, of which the one is dependent on the preparation costs, and the other on the production costs. The "step tariff" system was originated by Dr. Kallmann, city electrical engineer of Berlin. The principle is that a certain number of units is consumed before a rebate is allowed, but it differentiates between the charge for units consumed when the load is heavy and those when the load is light. The "Halle" tariff is independent of the size of the installation and of the actual consumption, thus placing both large and small consumers on the same footing. The "two rate" system makes two distinct charges based on the time of day when current is taken. The slot "prepayment" system involves the use of automatic meters. The "hour meter" system described is well known. The book contains over 300 pages, is well indexed, and the various types of meters are very fully illustrated and described.

Air Compressors and Blowing Engines. By Charles H. Innes, M.A. Dm. 8vo., pp. 290. Manchester and London: The Technical Press, Limited. 1906. Price 4s. 6d.—This volume is a reprint of a series of articles that have been published from time to time in the *Practical Engineer* dealing with the construction of blowing engines and air compressors. The first chapter discusses the mechanics of air compressors and develops the analytical methods for the calculation of the leading dimensions of engines for different requirements. The second reproduces the numerical data of a series of trials made with different kinds of air compressors, and gives the methods of deducing the mechanical efficiency from such data. Then follow descriptions of blowing engines and compressors, with detailed illustrations of their valves and other characteristic features. Many of these are reproduced from accounts published in the leading British and foreign technical journals, but in others, more particularly in the section on compressors, valuable contributions have been made by different manufacturers. By the use of a severely compressed literary style well in keeping with the subject, the author has managed to bring a large amount of information into a small compass and a cheap and handy form. The section on blowing engines is, however, decidedly behindhand, as no mention is made of the so-called quarter-crank system of construction, which has been developed on a considerable scale

in Cleveland for some time past; and the gas blowing engine is only very feebly noticed in a description of a Körting gas motor, which does not, however, appear to have been connected with a blowing engine. The compressor section is much better brought up, and fairly represents the actual practice in this important subject.

The "Electrician" Wireman's, Linesman's and Mains Superintendent's Pocket-book, 1906-1907. By Charles Raphael. London: The *Electrician* Printing and Publishing Company, Limited, Salisbury-court, Fleet-street. Price 5s. net.—The contents of this pocket-book have been revised and many parts entirely re-written. The book has now been divided into seven sections. These include House Wiring, Underground Lines; Overhead Lines for Electric Light and Power Distribution; Telegraphy and Telephony; Electric Tramways; Electricity in Mines; Electric Bell and Interior Telephone Wiring; and Miscellaneous. Among the chief additions may be mentioned a set of diagrams for the connection of motors to supply mains. A table of voltages on two-phase and three-phase systems, and an important section on Electric Tramways. There are a large number of illustrations and diagrams which greatly add to the value of the handbook.

The Building Mechanic's Ready Reference. By H. G. Richey. London: Chapman and Hall, Limited. Price 1·50 dols. net.—This is a useful reference book for the carpenter and woodworker. As much as possible of the information is tabulated, and the diagrams have been made without unnecessary detail, which renders them more easily read. The index is good, and care has also been taken in the arrangement of the matter. The book is divided into six parts. The first deals with short methods of laying out work. The second gives time-saving tables and various condensed data. A few short cuts and useful problems for the carpenter are described in the third section. Part IV. contains lumber tables, strength of wooden and steel beams, columns, &c. The strength and weight of various materials used in carpentry are given in Part V. Finally, the author gives numerous receipts, hints, and mensuration tables.

The Economics of Railroad Construction. By Walter Loring Webb. London: Chapman and Hall, Limited. Price 10s. 6d. net.—This is an American book which deals with the economics of railroad construction. It is assumed that those who read this book are already familiar with the mechanical processes used in railroad surveying and construction; that they know how to survey a line, and how to build it, as thus laid out. The book has been written from the standpoint of the constructing or operating engineer. Legal considerations have been avoided, or only introduced where it has been found necessary. There are three sections—the financial and legal elements of the problem; operating elements; and physical elements. These general headings have been sub-divided into numerous chapters. The various problems have been carefully chosen and dealt with in a full yet concise manner.

The Anatomy of Bridgework. By William Henry Thorpe, Assoc. M. Inst. C.E. London: E. and F. N. Spon, Limited, 57, Haymarket. Price 6s. net.—This book is a compilation of a number of articles that have recently appeared in our contemporary, *Engineering*, on the subject of bridge design. The author has collected much data relating to bridges that have already been constructed, and he gives many interesting phenomena which he has observed in old bridges and their component parts. The author strongly advocates the study of old bridges, especially with respect to stress and strain, pointing out that consideration of existing work may be a useful check upon the fanciful requirements of some methods of design. The treatment of the subject is original, yet the author, besides making the book most instructive, has also made it interesting. The illustrations are also good.

The "Mechanical World" Pocket Diary and Year-book for 1907. Manchester: Emmott and Company, Limited, 65, King-street; and London: 118, Chancery-lane, W.C. Price 6d. net. This is the twentieth year of publication of this useful little book. It has been thoroughly revised and brought up to date. It contains, amongst other things, an entirely new and lengthy section on gas engines, and a new section on oil engines is also embodied. The question of suction gas producers is dealt with at some length. Among other new matter are to be found tables and data on worm gear, wire ropes, crane hooks, chords of angles, proportions of rope wheel grooves, &c. No praise of ours is necessary to commend this book of reference to its many users.

Tables of Five Place Squares and Logarithms of Feet, Inches, and Thirty-seconds of Inches from Zero to 100 Feet. By S. D. Inskip. New York: The Myron C. Clark Publishing Company, 13-21, Park-row.—These tables are extremely neat and clear, and have evidently been compiled with great care. The book contains squares and logarithms of feet, inches, and thirty-seconds of inches from zero to 100ft. Logarithmic secants from zero to 18in. rise to 1ft base advancing by thirty-seconds. Logarithmic functions, natural sines and cosines for every minute of the quadrant are also given. The tables have been nicely arranged, and the figures are printed in bold type.

Iron, Steel, and Fireproof Construction. By Paul N. Hasluck. London: Cassell and Co., Limited. Price 2s.—This book is a reprint of articles which have appeared from time to time in the *Building World*. The first few chapters deal generally with the design of stanchions, columns, and foundations, showing also how their weights and the loads they have to carry are determined. As the book proceeds, the more practical questions involved are considered. The last five chapters deal with fireproof structures clearly and well. The book throughout is nicely illustrated, and the descriptions of the different structures, and the calculations involved in their design, are given clearly and concisely.

C. H. Bailey's Handbook of Useful Information. Can be obtained from Mr. Bailey, Tyne Engine Works, Newport and Barry Docks. Price 7s. 6d.—We have received from Mr. Bailey this handy little reference-book which gives useful information on mechanical and marine problems. The book appears to have been compiled more for the marine than for the land engineer, the greater part of the book being devoted to marine subjects.

NOTHING short of the utmost vigilance on the part of the medical authorities can maintain satisfactory health conditions in the city of Manila. In that city, with a population of 219,941, including 4389 Americans, 189,782 Filipinos, and 2528 Spaniards, there were, during the quarter covered by the present report, 1848 deaths, being an annual death-rate of 33·72 per 1000 of population, against a rate of 30·09 for the quarter preceding.

A NEW 4·7 INCH SIEGE GUN AND CARRIAGE.

THE 4·7in. siege gun and carriage which has recently been constructed in America, and which is now undergoing its trials, was designed to replace the service 5in. gun. Briefly stated, this new gun, as described in the *Journal of the United States Artillery*, consists of a gun of 4·7in. calibre, firing a 60 lb. projectile with an initial velocity of 1700ft. per second, and recoiling 66in. upon the carriage, which remains stationary under the firing stress. The recoil of the gun upon the carriage is checked by a hydraulic buffer, and the return movement is accomplished by springs. The movement of the carriage upon the ground is prevented by wheel brakes and by a trail end spade.

The gun is a built-up steel rifle 135in. long, it weighs

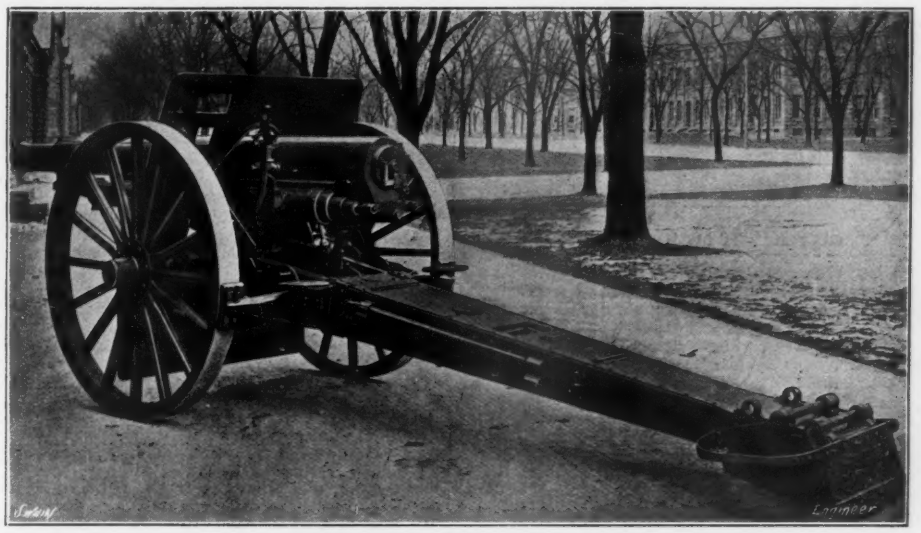


Fig. 1—THE GUN CARRIAGE READY FOR ACTION

1730 lb., and consists of a tube, jacket, locking hoop, and front clip. On the lower side of the barrel, and extending the entire length of the jacket, locking hoop and clip, are formed two recoil guide clips which engage under, and secure the piece to, the guide rails of the cradle. On either side of these guide clips the jacket and locking hoop are provided with broad longitudinal bearings, which rest on bearing rails on the cradle. These bearing rails are placed well up on either side of the gun, and are therefore so far apart as to afford lateral steadiness to the gun in transportation as well as in action. A stout lug on the lower side of the jacket at its rear end provides a place for the attachment of the piston-rod of the carriage.

The gun is fitted with a breech block of the interrupted screw type with four threaded and four planed sectors. When the breech is opened the block is supported by the usual form of carrier, hinged to the right side of the jacket.

The firing mechanism is of the continuous pull type, in which the firing pin is cocked and fired by a single pull of the lanyard or stroke of the firing lever. The firing pin is excentrically placed in the block, and the breech-block recess in the gun is also excentric with reference to the main bore. When the breech is closed the firing pin lies in the axis of the piece opposite the percussion primer of the cartridge. As the block is rotated to open the breech, the pin is moved to one side clear of the primer, and remains in that relative position until the block is rotated back in closing the breech. This device ensures safety from a premature discharge due to the protruding point of a broken firing pin striking the cap as the block is swung to its seat in closing.

The wheels of the carriage are of the Archibald pattern, and are 60in. in diameter, and 5in. wide on the tire. Exhaustive tests, recently concluded, are said to have indicated that no practical advantage is gained by using wider tires on vehicles of this class and weight. The trail is 140in. in length and is of the usual construction. The spade at the end is constructed of steel, and has a large bearing surface to prevent recoil of the carriage along the ground, and broad horizontal wings or floats to prevent excessive burying in the ground. It is of the folding type, being hinged on the top of the trail at its rear end. For travelling it is turned up, and rests on the top of the trail. For firing it is turned down, and in either position is held in place by a heavy key bolt. The pintle yoke rests on the pintle socket at the front end of the trail—in front of the axle—and is secured by circular clips in such a manner that it is free to turn about its vertical axis. A traversing bracket rigidly bolted to the lower end of the pintle yoke extends under the axle back between the flask and forms a lever for the application of the traversing effort, as well as a support for the traversing screw and the elevating mechanism.

The rear portion of the traversing bracket is supported by two stout cross transoms, on which it slides in azimuth and to the rear one of which it is clipped. The crosshead of the double-screw elevating device rests on its trunnions in the portion of the traversing bracket between these two transoms. As a result of this arrangement, the elevating mechanism moves with the traversing bracket when the cradle and gun are traversed. It is thus always directly under the weight which it supports, and all cross strains are avoided. The down thrust of the elevating screws is taken by the cross transoms referred to. The middle tube of the cradle is the hydraulic cylinder for checking recoil. The two outer tubes contain the counter recoil springs. Each spring cylinder contains three concentric columns of helical springs formed of round wire. The front end of each column is connected to the rear end of the one within by a steel tube or stirrup, which acts as a guide rod for the springs of the outer column. The rear end of the outside column abuts against a shoulder on the cradle. The front end of the inside column of springs abuts against a shoulder on the spring rod on which the springs are assembled. The rear ends of these spring rods—one for each spring cylinder of the cradle—are secured to a cross bar or yoke, which rests against the rear face of the recoil lug on the gun.

This method of using concentric spring columns connected by stirrups, so as to work tandem and to telescope when at rest, has the advantage of compactness and gives a very long spring stroke with short assembled length of column. The springs are assembled under sufficient compression to return the piece to battery position at a maximum elevation—15 degrees.

The gun, upon being fired, moves 66in. to the rear upon the cradle, carrying with it the piston and the spring rods. The recoil cylinder, placed in the cradle directly under the gun and guarded upon either side by the spring cylinders, is thoroughly protected from injury. It is simple and compact and has no moving parts to get out of order, and no exposed working surfaces to catch dust and dirt. It has but one stuffing-box, which is readily accessible for adjustment or repacking. The carriage is fitted with hardened steel shield, 0·2in. thick, covering the space between the wheels to a height of 68in. from the ground. The bullet-proof quality of each plate is demonstrated by actual test before the plate is accepted. The main shield plates are rigidly attached to axle brackets and braced from the trail. The top and apron shields are hinged to the main shield; the former is folded down and the latter is swung under the axle for travelling.

The arrangements for aiming the piece comprise open sights, a panoramic sight, and a range quadrant. They are supported by brackets attached to the cradle, the open sights with the panoramic sight on the left side, and the range quadrant on the right side of the piece. For travelling—see

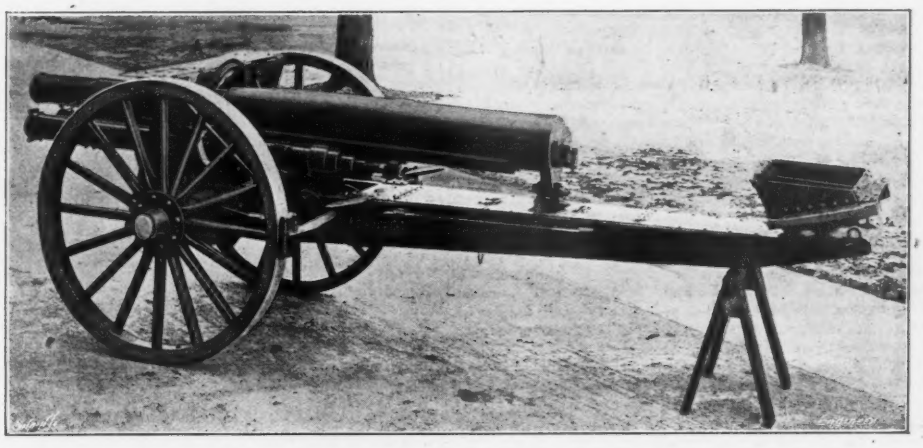


Fig. 2—THE GUN CARRIAGE IN TRAVELLING POSITION

Fig. 2—the gun is disconnected from the piston and spring rods and shoved back 40in. upon the cradle. In this position the recoil lug is secured between two braces attached to a heavy trail transom. The breech of the gun is thus so supported and rigidly held in travelling that the elevation and traversing mechanisms are relieved of all strains. The braces referred to are pivoted in the trail, and when not in use are turned down inside the trail. The weight of the carriage complete is 4440 lb. and that of the gun and carriage 7170 lb. The weight at the end of the trail, gun firing in position, or the weight to be lifted in limbering up, is 400 lb , with the gun in travelling position this is increased to 1150 lb., which is the portion of the carriage weight sustained by the limber. The weight of the gun-carriage and limber complete is 8000 lb.

The ammunition used with this gun has the powder charge in a metallic case combined with the projectile into a single cartridge. The case weighs 7·75 lb., the projectile 60 lb., and the complete round 73·75 lb. High explosive shell and shrapnel are used. The elevating mechanism provides for elevation from − 5 deg. to + 15 deg.; greater elevation may be obtained by sinking the end of the trail in the ground. The range corresponding to an elevation of 15 deg. is 7600 yards, and the remaining velocity at that range 850ft. per second. Since the bursting charge of the shrapnel gives its bullets an additional velocity of about 250ft. per second, the shrapnel fire at extreme ranges is most effective. The engravings show the carriage ready for action and the carriage and gun in travelling position.

OUR MINERAL STATISTICS.

As has been our wont for some years, we give herewith a review of the somewhat belated British mineral statistics, issued as Part III., "Output," of the Mines and Quarries General Report and statistics for 1905. Owing to considerations of space, no reference will be made to the coal and iron trade statistics, which form a prominent part of the returns, attention being limited to the output and position of metalliferous ores and a few non-metallic minerals. With regard to the few explanatory words which precede the actual statistics for each substance referred to, it has been suggested in former years in this review that they might occasionally be brought up to date. It is interesting to note—though the assumption is not made that it is a case of cause and effect—that alterations are now to be found in two or three cases. All the same, we think there is still room for improvement, notably with regard to manganese ore and chert, substances which will be referred to again later. Although, in a general way, higher prices for metals stimulate activity in mining, this is not always the case, and it is important to note the individual mines or districts where enhanced profits are due simply to higher market values, and where they are the result of increased output. The rise in the price of metals has been much more pronounced in 1906 than in 1905, and there is not so much to note in the way of reopening abandoned mines in the report now before us as will assuredly be the case in the forthcoming one.

The influx of South African capital into Cornwall ought to dispose of the widely-held, but erroneous, idea that the tin lodes of the duchy are worked out, and there seems little doubt that if sufficient capital were forthcoming other mining districts, now either deserted or dragging out a precarious existence, could be made to show satisfactory returns. Of course, during the present boom in copper and lead the company promoter has been active, and numerous propositions, good, bad, and indifferent, have engaged his assiduous attention. A metal mine to be a financial success need not necessarily have a large capital, although it is, of course, important that sufficient funds shall be available to carry out the proposed scheme of operations. Especially is this the case with lead mining, in which the results from handdressing the ore approximate very closely to those obtained with machinery on a large scale and of the latest type. This is, of course, apart from the actual output. For this reason it is unfortunate that in so many cases the prosperity of a small mining concern is so often jeopardised by a large amount of its capital representing commissions paid to those who have been instrumental in forming the company. Despite the present high prices of metals, the uncertainty as to how long they will be maintained is the main factor which is operating against capital being obtained for properties which require a considerable expenditure on pumping before they can enter the producing stage. This hesitancy is not, of course, apparent where it is proposed to sink on a proved virgin lode, or where the scheme is the re-working of old dumps. A good deal is being done in the latter way, and there is every prospect of Swaledale emulating what has been done with success in Shropshire and North Wales. For the recovery of lead and zinc ores from dumps, up-to-date plant running well into four figures is desirable, if not absolutely essential; but where the dumps have been carefully sampled, the expenditure of capital on concentrating plant involves much less risk than where the ore is being mined, and where pinching or heaving of the lode presages a period of great anxiety. With regard to magnetic separation, this has completely vindicated the faith of those who were prominent in its introduction into Cornwall for the separation of wolfram from tin. So far little has been done in other mining districts, but several experiments have been made with the complex zinc ores of North Wales, and a Dawes magnetic separator will very shortly be in operation at a Cardiganshire mine, where the prevalence of iron pyrites in the blende is a source of trouble. With regard to Derbyshire, where the "nicking" of unworked mining setts by the barmaster has inspired so many articles in the Press, an extension of the lead mining industry seems imminent, though when one reads about a revival of an extinct industry it is clear that the position is not accurately gauged. As a matter of fact, the actual output of ore, though practically all from one mine, the Mill Close in Darley Dale, has for some years been in excess of that of old days, when numbers of mines were working in the High and Low Peak districts—that is, as far as statistics bearing upon the point are available.

But to turn now from the general to the particular, it will be convenient to take our references in alphabetical order, and a commencement may fitly be made with arsenic. From the returns for arsenical pyrites, nothing of any value can be gleaned, owing to the inclusion of mixed tin, copper, and wolfram ores containing arsenic. This difficulty, with which the compiler of the statistics is not concerned, makes it impossible to state the amount of arsenical pyrites produced, but it would appear that as far as the mineral itself is concerned, the output shows really no increase over that of 1904, the lowest for thirty years. In the refined product known as white arsenic, there is a rise from 976 tons in 1904 to 1528 tons in 1905, which is encouraging, although, of course, the figures are much below those which ruled only a few years ago, before two or three other countries became prominent producers. The output of barytes, 29,063 tons, is rather above the average for the past few years, but as there is nothing that calls for particular mention with regard to this mineral, we may pass on to chert. This is still referred to as being obtained principally from carboniferous strata in Derbyshire and Flintshire, though as the output from the Yoredale strata in Swaledale amounts to 900 tons, compared with the 1254 tons from Flintshire, it would seem that Yorkshire is entitled to specific mention as a producing county. The Bakewell district of Derbyshire remains the principal producer, with an output of 3820 tons. The figures for chert and flint are lumped together, but a little expert knowledge allows of their dissection, and we shall not be far wrong in saying that the chert output rose from 5000 tons in 1904 to 6000 tons in 1905, a clear indication of increased activity in the pottery trades, where the stone is used as a grindstone in the wet-grinding mills. Chert has recently come to be used increasingly as a road metal, though for this purpose the material supplied is of very much lower quality than that which is specially mined and quarried for use in the Potteries.

Passing on now to copper, a considerable increase in the values is seen, but the output of ore also rose from 5276 tons in 1904 to 6903 tons in 1905. For the first time for many years Yorkshire figures as a producer, 251 tons of 8 per cent. ore having been got from the small mine at Richmond. Tipperary is the other new producer we notice, with 35 tons of 28 per cent. ore. From information to hand concerning the present year, we are in a position to say that both the Swaledale and Tipperary mines, which are as yet only in the development stage, will show increased figures in the next report. Two or three promising copper properties are also being developed in North Wales, and altogether the outlook indicates that British copper mining is by no means doomed to that rapid extinction predicted of it a few years ago. In one way or another the reopening of the old Bonmahon copper mines in Waterford has formed the subject of a good deal of Press comment. That there still remains plenty of ore in the property will be seen in the returns for the present year, though as it is of comparatively low grade, the future of the concern must depend a good deal on the prices ruling for the metal. The conditions under which the ore is found in Waterford admit, however, of cheaper production than is the case with the Tipperary product, which has an assay value of 25 to 32 per cent. as mined, without the use of any concentrating machinery. Proceeding to fluor spar, a further considerable increase in production is recorded, especially in Derbyshire. With regard to the uses of fluor, the report only mentions "Blue John," a material for ornaments. Of course, the amount of this high-priced variety forms a very small fraction indeed of the Derbyshire output of over 34,000 tons. The present demand for fluor rises from its increased use as a blast furnace flux, and also for other purposes which come somewhat in the category of trade secrets. The figures for Derbyshire show that 34,347 tons were derived from mines and 110 tons from quarries, but we think we are correct in our surmise that the bulk of the mineral obtained has not actually been mined, but has been got from the waste heaps of the old lead mines in the Bradwell and Hucklow district. The bulk of the Durham production, on the other hand, is obtained as a by-product in the Weardale lead mines.

The results of gold mining in North Wales in 1905 form very melancholy reading after the spurt of the preceding year, the value of the ore crushed falling from £68,576 to £17,787. As the ore mined only fell from 23,000 tons to 16,000 tons, it is evident that there has been a considerable falling off in assay value, and the Merionethshire mines must therefore rank, as before, as extremely speculative investments. Although the results in the present year cannot be considered as encouraging, the St. David's mine is pluckily continuing work, and it is to be hoped that better ground will be struck to reward the efforts of the management.

The output of iron ore shows a rise of 816,421 tons to 14,590,703 tons, which is somewhat above the average of the last few years. The imports of iron ore rose from 6,657,884 tons in 1904 to 7,868,845 tons in 1905. Glancing at the table of countries whence imported, a rise of over a million tons is credited to Spain, while the always small import from Portugal has sunk from 6000 tons to 1000 tons in round figures. It is not clear whether the figures for Norway represent ore produced in that country, or include the produce of mines in Swedish-Lapland shipped from Narvik. As the export of iron ore concentrates from the Dunderland mine to the North-east of England did not commence until this year, the rise of about 100,000 tons in Norway's exports cannot have been brought about or contributed to by the Dunderland Company; and as the Swedish exports to Great Britain show a reduction, it is quite possible that variations have occurred with regard to ports of shipment.

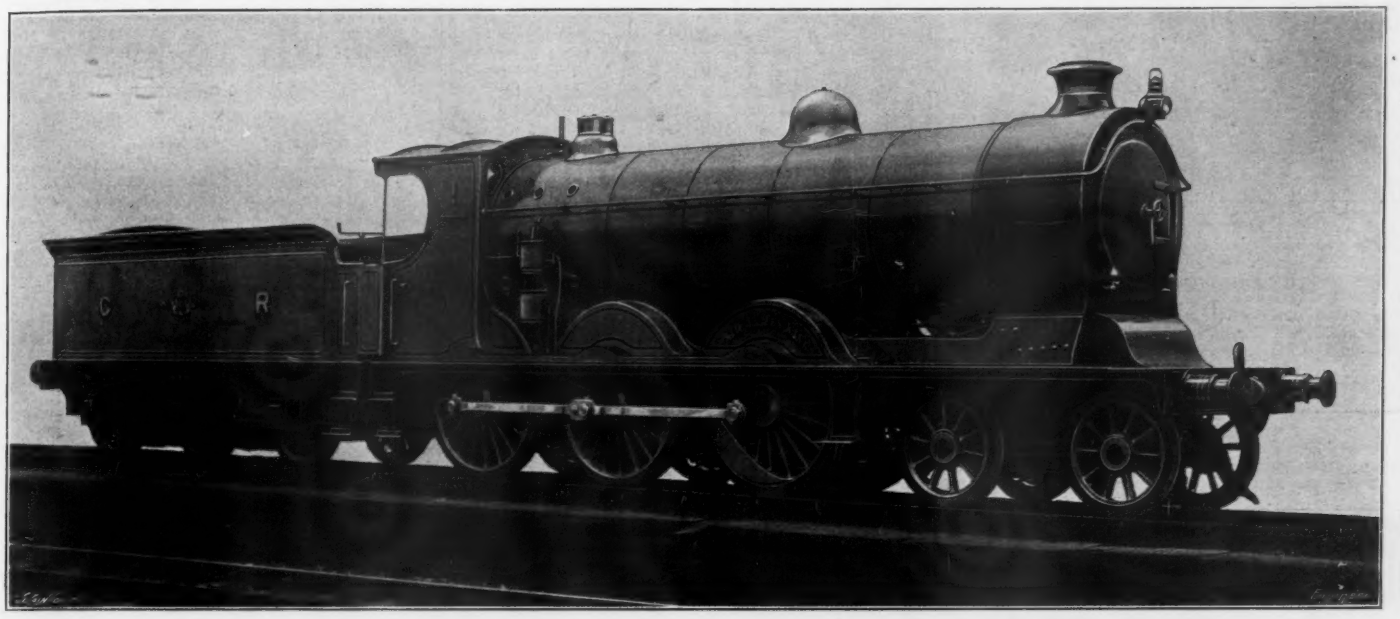
Turning to lead, the total of 27,649 tons of dressed ore represent a rise of 1275 tons over the preceding year. Perhaps the most notable individual return is from Derbyshire, where there is a decrease of about 1000 tons—that is, from 6000 odd to 5000 tons. Although the ore was obtained from several mines and is lumped together in the return, it is well known that nearly all of it came from the Mill Close mine, which, even with the reduction just mentioned, easily retains its position as the leading lead mine in Great Britain and the Isle of Man. In North Wales, while the Halkyn mine shows a reduction, our prediction of last year respecting the Rhosesmor mine as a possible rival to Mill Close for first place finds justification in the increase from 1897 tons to 2829 tons. Respecting the column giving assay values of the dressed ore, there is something peculiar about the Central Halkyn mine. In 1903 it was stated that this mine dressed up to 89 per cent., while last year it has gone one better, the figure given being 90. *Primâ facie* there is something wrong here, as the theoretical figure for pure galena is 86·6 per cent., but, of course, there may be a satisfactory explanation of an apparent anomaly. Another point that calls for notice is in connection with the Glentogher lead mine, in Donegal, a newcomer, by the way, in these returns. The 400 tons of dressed ore, value £4800, are given as having an assay value of 25 per cent. lead. There is evidently an error here, even when a liberal allowance is made for the 10 oz. of silver to the ton which the ore is stated to yield. It requires a good deal of persuasion to get smelters to buy ore of low grade, and in the North of England, at any rate, they will not touch ore of less than 50 per cent. lead. Not much has been done so far in North Wales to take advantage of the present boom in lead, though we note that the Rhydwen mining sett near Holywell, which produced a considerable amount of ore from a shallow shaft before its abandonment about twenty years ago, has been taken over by a new company with a view to proving its potentialities in depth.

Turning to the North of England, a satisfactory increase is shown in the output of the Wiregill Deep mine in Teesdale, where the new company, which took the property over when the London Lead Company abandoned the district, has had engineering difficulties of considerable magnitude to contend with. The Greenside mine in Westmoreland shows an increase, and its high yield of silver is well maintained. The Alston Moor mines in Cumberland have the comparatively poor return of 568 tons of ore, but there is reason to suppose that the lead mining is being purposely neglected in favour of zinc. The manganese ore output fron Carnarvonshire rose from 8756 tons in 1904 to 14,474 tons in 1905; moreover, the value of the ore was considerably higher. This is the largest amount of ore raised since these statistics were initiated, and the largest monetary value since 1876. Seeing that the output in 1903 was only 818 tons, one may be pardoned for suggesting that the headline to the manganese returns, in which it is stated that our deposits are unlikely to be extensively worked, might undergo some alteration. It certainly is the case that abundant supplies of far richer ores are found in Russia, India, and Brazil, but despite this, the Welsh low grade ore finds a ready sale not only in Great Britain but on the Continent, and it is also being shipped to America. This is not the place, even if space permitted of it, to enlarge on the question of manganese supplies generally. We have merely drawn attention to the facts with regard to the Welsh production. In next year's returns a reduction will probably be seen, as the principal producer, the British Manganese Company, of Rhiw, has ceased work for some months now, from reasons which have nothing to do with the ore supply, which from all accounts is likely to prove plentiful enough. There is not much in the present report to testify to the revival of tin mining in Cornwall; we shall have to wait a year or two before witness is borne to the present activity in the returns. All the same, the output for 1905 is considerably in excess of the preceding year, being 7201 tons against 6742 tons, the difference in value being nearly £100,000. Dolcoath, the leading mine, shows a very slight reduction in output, but this is amply compensated for in value, the average value of black tin—dressed tin ore—having been £79 14s. 8d. in 1905, against £71 2s. 10d. the preceding year. Turning to uranium, it is stated that 103 tons of ore of unascertained value were obtained from the waste heaps at the uranium mine in Cornwall. Presumably this is the Grampound Road mine, where nothing was produced in 1904. No doubt the business has received a fillip since the advent of radium. The output of wolfram shows a small rise from 161 to 171 tons, though the value is £11,000 odd against £14,800. Although wolfram is so largely used in the Sheffield district in steel-making, there are great market fluctuations in the price, and the uncertainty as to value has proved a set-back in its mining. A good deal is being got in Queensland, and the output in the North of Spain could certainly be largely increased with the encouragement of more stable markets.

Zinc ore shows a material decline from 27,655 tons to 23,909 tons, though the value is rather more. The returns from Flintshire are almost exactly the same as in 1904, viz., 3913 tons in the aggregate; but looking at the individual mines, we see some important changes. The production of the Halkyn mine shows a considerable falling off, while the Milwr has to record a large increase. The latter is an old property near Holywell, which has had a tunnel driven to it from Bagillt. The tunnel serves the double purpose of drainage adit and tram road for taking the ore direct to the dressing floor at Bagillt, and those who financed the scheme, which was one of some magnitude, are to be congratulated on the result of their enterprise. The Minera mine at Wrexham, long the principal zinc producer, is easily distanced by the Nenthead mine on Alston Moor with its 5609 tons, and the Carshield mine, not far off in Northumberland, with its 3096 tons, puts the Minera now into the third place. With regard to the

SIX-COUPLED BOGIE PASSENGER ENGINE—CALEDONIAN RAILWAY

MR. J. F. McINTOSH, GLASGOW, ENGINEER



Welsh figures, a considerable amount of blende is being got from the waste heaps, this being notably the case at the Trelogan mine, near Llanasa. There is nothing much of note to record respecting new zinc enterprises, though the Snailbeach mine in Shropshire appears likely to show an increased output, and the development work which has been actively carried on near Llanrwst by the North Wales Spelter Syndicate, Limited, has proved the existence of valuable ore bodies in ground abandoned by previous companies.

SIX-COUPLED BOGIE PASSENGER ENGINE—CALEDONIAN RAILWAY.

A NEW type of passenger engine has just been produced to the designs of Mr. J. F. McIntosh, at the St. Rollox Works of the Caledonian Railway. This engine, which is illustrated in the accompanying engravings, is of the 4–6–0 type, with inside cylinders driving on the front axle of the coupled wheels. The coupled wheels are 5ft. 9in., and the bogie wheels 3ft. 6in. in diameter. The boiler barrel is 15ft. 8⅜in. long by 5ft. 3¼in. in diameter. The tubes are of mild steel, galvanised, 242 in number, and 2in. external diameter. The fire-box shell is 6ft. 11in. long by 4ft. wide at bottom, and the crown is stayed with direct stays. The group of four safety valves are 4in. in diameter, with independent springs adjusted to blow off at the working pressure of 180 lb. per square inch.

The cylinders, which are inside the frames with the slide valves between, are 19in. diameter by 26in. stroke. The piston-rod and valve spindle stuffing-boxes are fitted with a patented metallic packing. The valve motion is the "Stephenson" link type, and the steam reversing gear is coupled direct to the reversing shaft. The built crank axle has journals 9¼in. diameter by 7½in. long, and the connecting-rod bearing is 9¼in. diameter by 4in. long. The intermediate and trailing axles have concave journals 7¾in. diameter at centre by 9¼in. diameter at ends by 12in. long. To allow a total side play of ½in. at the trailing wheels, flexible coupling rods are provided. The engine, which is known as 908 Class, is equipped with the usual Westinghouse air brake fittings complete. Also an ejector and "through" vacuum brake pipe.

The following are its principal dimensions, &c.:—

Engine.

Cylinders—	
Diameter	1ft. 7in.
Stroke	2ft. 2in.
Wheels—	
Diameter on tread (bogie)	3ft. 6in.
Diameter on tread (coupled)	5ft. 9in.
Boiler—	
Height of centre from rail	8ft. 6in.
Length of barrel	15ft. 8⅜in.
Diameter of barrel	5ft. 3¼in.
Thickness of barrel plates	⅞in.
Fire-box shell—	
Length outside	6ft. 11in.
Breadth at bottom	4ft.
Depth from centre at front	5ft.
Depth from centre at back	4ft. 3in.
Thickness of plates, sides	⅜in.
Thickness of plates, crown	⅜in.
Tubes—	
Number	242
External diameter	2in.
Distance between tube plates	14ft. 11⅞in.
Height of chimney above rail	12ft. 11in.
Heating surface—	
Fire-box	128 sq. ft.
Tubes	2050 sq. ft.
Total	2178 sq. ft.
Grate area	21 sq. ft.
Working pressure	180 lb. per sq. in.
Weight of engine in working order	64 tons

Tender.

Capacity of tanks	3570 gallons
Fuel space	4½ tons
Diameter of wheels	4ft.
Weight of tender, full	38 tons
Weight of engine and tender in working order	102 tons
Length of engine and tender over buffers	58ft. 11in.

The first engine of this series has been named Sir James King, in compliment to the chairman of directors of the company, and we may mention that it is the third distinct type of engine to be turned out at St. Rollox works this year.

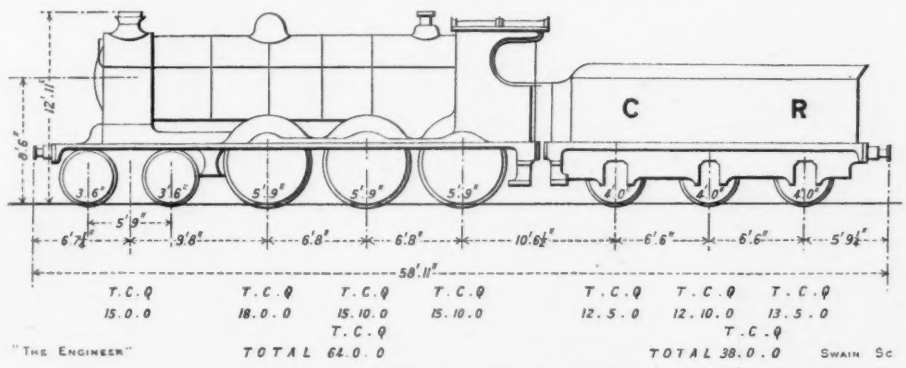


DIAGRAM OF CALEDONIAN RAILWAY LOCOMOTIVE

SEWAGE DISPOSAL AT DERBY.

THE new works for the disposal of the sewage of Derby were sanctioned by Parliament in 1901, and are now practically completed. A large proportion of the sewage of the borough is now being treated at the sewage disposal works, and there only remains the completion of the interception of the sewage which up to the present time has found its way direct into the river Derwent and the other watercourses flowing through the town. The works have been in hand for four and a-half years, and comprise the following:—Intercepting sewers, pumping station buildings and machinery, sedimentation tanks, percolating filters and storm-water filters, together with all the necessary culverts, overflows, &c. Up to the present time a sum of £235,000 has been expended on the actual works.

The following description of the condition of affairs before the new scheme was commenced, and of the works which this scheme included, will be of interest to our readers:—

The existing sewers in the Borough of Derby convey sewage and also rain water running off the roofs, yards and roads, and discharge this liquid into either the culverted brook courses which run through the town or else direct into the river Derwent within the boundaries of the borough. The new scheme provides for the interception of the sewage and a certain proportion of the rain water by means of new sewers which will carry the fouled liquid down the valley to Spondon, where it will be treated bacterially. At the present time the population may be taken at 120,000, and the water supply is under 25 gallons per head per day.

The intercepting sewers are designed of such a size as to be capable of carrying down to the overflow chamber at Alvaston at least 12 volumes, calculated on a future population of 180,000 at 30 gallons of sewage per head per day. Any excess over this quantity will overflow into the nearest brook course or into the river in the borough. From the Alvaston overflow chamber, a 6ft. by 4ft. egg-shaped sewer convey the sewage to the pumping station, where pumping plant is provided capable of lifting at least 6 volumes of sewage and rain water into the tanks or on to the storm water beds for treatment. The excess over the 6 volumes up to 12 volumes will be allowed to overflow into the river at the Alvaston overflow.

The present instalment of pumping plant consists of three "main" engines—room being left for a fourth—driving three-throw plunger pumps each capable of raising 600 cubic feet of sewage per minute from the sump into the tanks, and three "storm" centrifugal pumps each capable of lifting 900 cubic feet per minute from the sump on to the storm-water beds. The sewage is pumped through a rising main discharging into a covered channel which runs along the south end of the tanks, and from this channel it is admitted into the tanks through openings controlled by sluices. The tanks are six in number, each being about 310ft. long and 37ft. wide, and each is divided by cross walls into three divisions. The total capacity of the six tanks is thus 4,320,000 gallons. Two more tanks can be added as required. At the outlet end the septic tank effluent, drawn from about 4ft. 6in. below top-water level, falls over a fixed weir into a covered channel, which conveys it to the continuous filters.

The present instalment of continuous filters consists of a range of eighteen, nine on each side of a double culvert, the upper one of which supplies the filters on each side, and the effluent from the filters is collected in the lower. The lower culvert is already carried far enough to allow of twelve additional filters being built, and these, of course, can be added as the necessity arises. The filters are circular, each 100ft. in diameter, the total area being about 15,660 square yards, and the average depth of the filtering material is 6ft. 7in. The sewage is sprinkled on the surface of the filters by means of revolving distributors. The side walls of the filters are built in honeycomb brickwork, and the filtering material is also aërated by three tiers of perforated pipes bedded in the material and brought to the face of the side walls.

The effluent from the filters is conveyed through a concrete culvert to the river, into which it is discharged through cast iron pipes controlled by valves. By means of the valves the effluent can be backed up in the culvert to a sufficient height to admit of its being turned on to the land. The storm-water beds are seven in number, and have an aggregate area of 25,100 square yards, the average depth of filtering material being 3ft. 3in. By means of a by-pass pipe from the outlet channel from the tanks, at least 2,000,000 gallons a day can be turned into the storm-water beds, and these beds can then be used as contact beds.

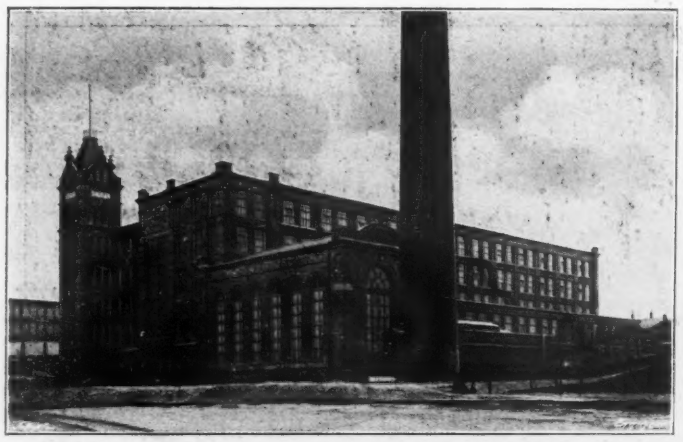
We are indebted to the courtesy of Messrs. James Mansergh and Sons, the consulting engineers, for the foregoing particulars.

SCANTLING RULES FOR YACHTS.

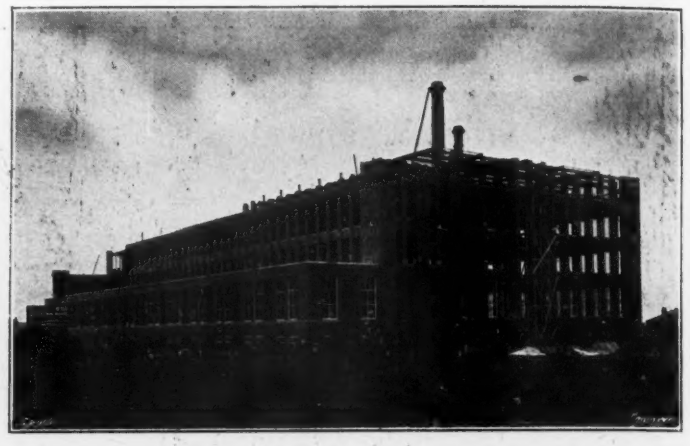
IN January, 1906, an International Conference on Yacht Measurement was held in London, when the following countries were represented:—Austria-Hungary, Belgium, Denmark, France, Germany, Great Britain, Holland, Italy, Norway, Sweden, and Switzerland. It was unanimously resolved at this Conference "that there should be scantling restrictions for racing yachts in all the countries represented, and Lloyd's Register was invited to confer with other classification societies with a view to coming to an "agreement on a uniform rule for the scantling classification of sailing yachts." It was also resolved "that it is necessary that all racing yachts be classed by the societies' rules."

Rules and tables have been prepared in accordance with these resolutions and have been agreed to by the classification societies, and are now ready for publication. The tables give the requirements for wood, steel, and composite yachts

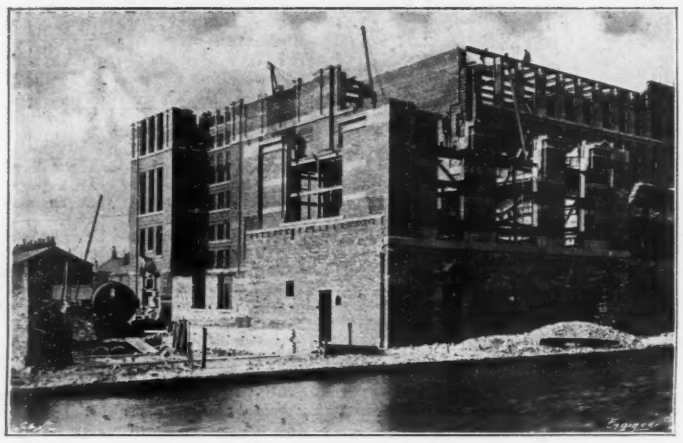
SOME NEW COTTON MILLS IN LANCASHIRE



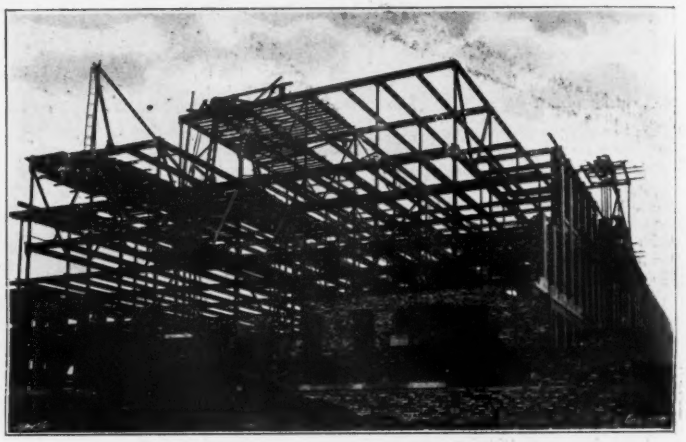
THE SOUDAN MILL, MIDDLETON



THE HERON MILL, HOLLINWOOD



ENGINE HOUSE, REGENT MILL, FAILSWORTH



IRONWORK, TEXAS MILL, ASHTON

BUILDING A 4,000,000 GALLONS WATER LODGE

SITE FOR THE MARLBOROUGH MILL AT FAILSWORTH

for each of the international rating classes from 5 m. to 23 m. inclusive, and are made out on the metric system as well as in the English measurements. It has been found necessary to prepare tables on both systems in order to ensure uniformity, as most continental nations use only the metric system, while in this country we still adhere to the English measurements of feet and inches. The greatest care has, we understand, been exercised in the preparation of the tables, and it will be found that the scantlings adopted, while providing sufficient strength, will not burden a yacht with unnecessary weight. As is well known, yachts built for racing purposes in recent years have been quite unsuitable for cruising, and when, through being outclassed by newer yachts, their racing career has ended, they have been almost valueless. This condition of things has seriously militated against the building of racing yachts. The aim in preparing the Rules and Tables now published has been to arrange for such scantlings as will enable a yacht to withstand the strains consequent on racing, and when her racing life is over to be converted into a useful and serviceable cruiser. In this connection it may be mentioned that yachts built to the uniform racing and scantling rules will be able to race on equal terms with yachts of the same rating classes in all the countries represented at the International Conference, in addition to which their scantling class will ensure their serviceableness as cruisers, and thus a considerably larger market will be afforded for yachts built to these rules than has hitherto existed for racing yachts or will be available for other yachts. Yachts built in accordance with these rules will be classed "R," denoting that the scantlings of the yacht are as required for the rating class to which she may belong.

In this country Lloyd's Register of Shipping will undertake the duty of classification. The constitution of this society is well adapted for the administration of the new rules. Experienced surveyors are stationed in all the yacht building ports, whose duty it will be, not only to see that the rules are complied with, but also to advise and assist the builders generally in carrying out the new requirements, and very complete instructions will be issued to the surveyors in order to ensure uniformity of practice in the different ports.

The International Scantling Rules may be obtained from the secretary of Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.

ENGINEERING IN COTTON MILLS.

A remarkable industrial development has been in active progress during the last year or two, and which continues to make headway. Enormous cotton mills are just now springing up in Bolton, Oldham, Rochdale, Chorley, and the suburbs, and the engineering outfits required are occupying the daily attention of thousands of engineers, mechanics, and fitters.

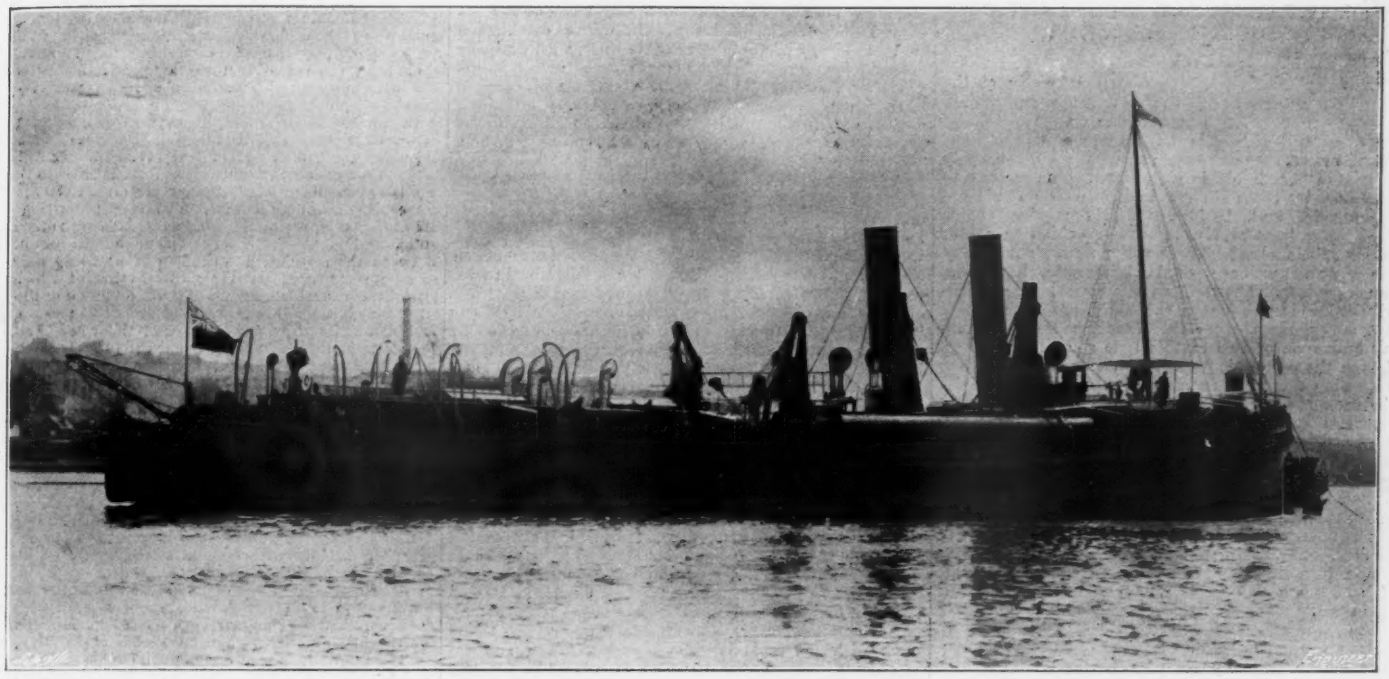
Lancashire is usually styled by business men the "Cotton County," with its metropolis at Manchester, connected by a ship canal to its great port of Liverpool. But everyone knows what an important part in Lancashire's industrial energies is occupied by the engineering trades. The manufacturing centres are replete with some of the largest and most up-to-date engineering establishments in the kingdom. Some of these employ from 4000 to 8000 men, and in them are produced week by week some of the most efficient engines and machinery that the world can purchase.

In all the seventy-odd large cotton mills which are now either completed or in course of erection—some of the largest factories that England can boast of—the engines and engineering appliances are local productions. Before transference to the new engine-rooms they have, in nearly every instance, been moulded, turned, finished, and temporarily erected in shops less than twenty miles away; and it should be remembered that if these engines were not of the first order, they would be unsuited to the perfect requirements of cotton spinning and manufacturing processes. In such mills there are engines of various dimensions, but they are mainly of the horizontal and marine types; a typical example of a horizontal steam engine as fitted to the smaller mills is shown on page 653. The engines being installed vary in power from 1500 to 2500 horse-power, according to the spindleage of the mills. Driving by ropes has always been much in favour, and some notion of its preference may be gleaned from the fact that a large percentage of the main fly-wheels in engine-rooms are grooved to take from 30 to 35 cotton ropes of about 1·5in. in thickness. The width of the rope race must, of course, bear a direct proportion to that of the fly-wheel periphery. The race reaches an altitude of 80ft. to 100ft. The fly-wheels are from 20ft. to 30ft. in diameter, and weigh generally over 25 tons. They revolve with a peripheral velocity of 5000ft. to 6000ft. per minute when run at full speed.

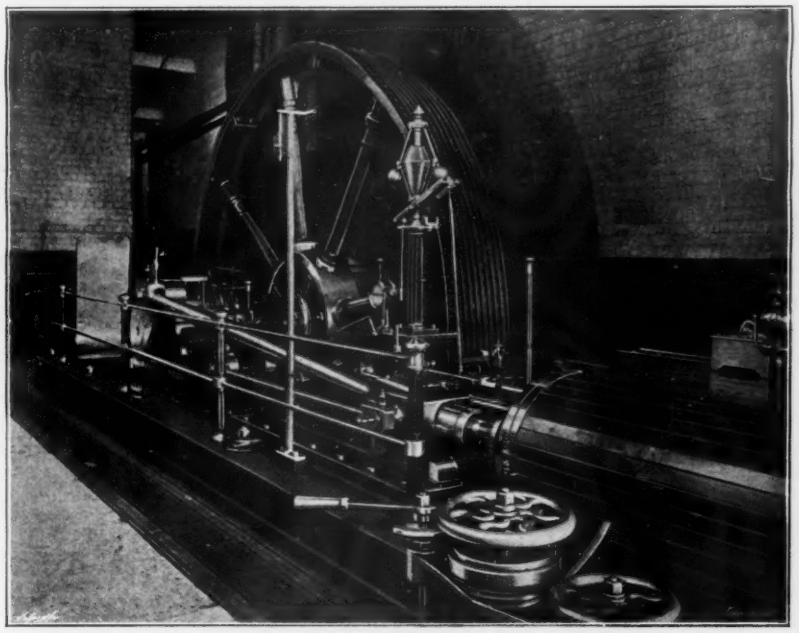
A fair specimen of details of the latest type may be given as follows:—A set of three vertical triple-expansion engines is erected in a cotton mill of 90,000 spindles; the driving

SUCTION AND DISCHARGING DREDGER SANDPIPER

WM. SIMONS AND CO., LIMITED, RENFREW, BUILDERS



load is 1000 indicated horse-power, at 75 revolutions per minute, with a boiler pressure of 180 lb. to the square inch. The diameters of the high-pressure, intermediate, and low-pressure cylinders are 18in., 30in. and 48in. respectively, and the stroke is 4ft. All three cylinders are fitted with Corliss valves and motion with tripping arrangements, each valve being independently adjustable. All glands and stuffing-boxes are fitted with metallic packings, and the cylinders are cased with sheet steel mounted on cast iron tablatures attached to the standards. The connecting-rods, of forged iron, are 9ft. between the centres; and cranks, pins, and shaft are made of Siemens-Martin steel. The pedestals, slides, and crank-pins are fitted with lubricators for forced lubrication. The condensing apparatus has one air-pump of 36in. bore, and a stroke of 16in. It is placed below the floor-level, and is worked from one of the main crossheads by steel-plate levers, links, and connecting-rod. The fly-wheel weighs over 30 tons, and is cased in radially



TYPICAL COTTON MILL STEAM ENGINE

with pitchpine boards. The engines are provided with stagings and ladders to give access to all moving parts and cylinders. Barring engine, Moscrop recorder, revolution counter and electric stop motion are also provided, the last-mentioned being particularly useful in case of accident.

A combination of this character weighs upwards of 180 tons, and as a type is seldom deviated from in important particulars. The factories have a fairly wide range from Blackburn to Ashton-under-Lyne.

The seventy new factories now under consideration are being constructed of a high standard of factory architecture, and well provided with arrangements for the health of the workers. Of the spinning mills the smallest contain 25,000 spindles, and from this number the figures rise to 120,000 in the largest factories. The total spindleage will be over 6 millions. When fully equipped the factories will have cost over 7 millions sterling, and 15,000 more operatives will be provided with employment. The new weaving sheds will be provided with 40,000 extra looms, for which 12,000 more weavers will be required. Half a million more bales of raw cotton will be called for annually, and the added weekly output of yarn will reach some 70 millions of miles.

The series of views on page 652 shows a number of the new mills in course of erection. These are interesting as showing the methods of construction employed.

DREDGING THE HOOGHLY.

By the operations of a large and very powerful suction and discharging dredger named Sandpiper, launched on the 19th inst. from the works of Messrs. Wm. Simons and Co., Limited, Renfrew, the Calcutta Port Commissioners hope to remove the difficulties of navigation on the river Hooghly. This dredger, which is 235ft. in length, has been specially designed for the unique character of the dredging to be done. The hull and machinery are constructed to Lloyd's highest class. The deck is of steel, sheathed with teak. Steam and hand steering gear is fitted, and a very complete installation of electric lighting is provided, including two searchlights.

The propelling and pumping engines are placed in two independent compartments. The propelling power is supplied by two sets of triple-expansion surface-condensing engines, embodying all the latest improvements in marine engine practice, including steam and hydraulic reversing gear, steam turning gear, independent circulating pumps, automatic feed pumps, feed heaters and filters, large evaporators for feed-water make-up, and a complete outfit of auxiliary feed and bilge pumps. Steam is generated by four large single-ended horizontal multitubular boilers, constructed to Lloyd's and the Manchester Steam Users' Association rules for a working pressure of 180 lb. These boilers are fitted into two stokeholds, communicating with each other. Steam ash hoists are fitted in each boiler compartment. The collective indicated horse-power of the twin engines is 4500. The pumping outfit, placed forward of the propelling engines in an independent engine-room, consists of two sets of triple-expansion ergines, with independent condensing plant and circulating pumps, complete with all modern fittings. The pump engines are coupled direct to two centrifugal sand pumps specially designed to raise and discharge altogether about 30,000 tons of sand and water per hour, the proportion of sand to water being 13 per cent. The reason for restricting the volume of sand to this amount requires some explanation, and constitutes what is perhaps the distinguishing feature of this notable new dredger.

The almost universal practice in carrying out dredging operations is, as is generally known, to dispose of the material raised in one or other of three ways, viz.:—(1) By discharging into the dredger's own hopper; (2) by discharging into hopper barges; (3) by discharging ashore for land reclamation. But at Calcutta it is proposed to discharge the material raised by the pumps directly into the river, the fast current of which, it is confidently expected, will convey the spoil to deep water before the sand has had time to settle. This expectation is based on actual experiments from which it has been found that the maximum quantity of sand that fast flowing rivers can carry in suspense is 13 per cent.

Each pump is connected to a separate suction pipe, placed one on the port and one on the starboard side of the vessel, each of the pipes being fitted at upper end with a massive swivel bend, which serves as a trunnion or hinge upon which the pipe is free to move, either vertically or horizontally. The swivel bends are carried in slides on the ship's side, which permit of the pipe and bends being brought completely inboard when required. Large sluice valves are fitted on the suction connections at ship's side, and the suction end of each pipe is fitted with a specially designed nozzle to suit the character of the material to be dredged, while a grid is also fitted to the nozzles to exclude material which might choke or damage the pump. Each suction pipe is controlled by two independent derricks, one for each end, and each derrick is worked by steam winches placed on deck, one on each side These are of most massive construction, having four independent drums arranged to work separately or together as required for lowering, hoisting, and derricking the pipes inboard, and they form one of the most important details for the successful working of a dredger of such large dimensions as the Sandpiper. They are so arranged that one man is capable of manipulating the whole of the movements.

The discharge pipes from each sand pump are carried aft under deck, and united into one large discharge pipe of 51in. diameter, which may be seen in our illustration projecting from under the vessel's counter. Special flexible connections are provided to meet the varying conditions between loaded and light draught of the dredger and the floating pipe line. The latter consists of 600ft. of 51in. diameter steel piping carried on twelve pontoons; each length of piping being coupled by cast-steel universal joints, designed to give flexibility in any direction.

One of the outstanding features of the deck equipment of this dredger is the extensive and powerful installation of mooring winches to regulate the movements in the rapid currents of the river Hooghly. The winches are placed at bow and stern, and consist of two duplicate sets, each having six independent drums and two ends for warping purposes. Two of the drums are arranged to work chains, and four are of very large diameter for working long lengths of heavy steel wire rope. Each winch is driven by a vertical high-pressure engine, the gearing throughout being of steel. A large workshop is fitted under deck so that all general repairs may be effected on board. The outfit of machine tools is very complete, and consists of lathes, shaping machine, radial drill, &c., also smith's forge, with mechanical fan, all driven by electric motors. A steam launch is provided for general service purpose, with special apparatus for lifting and laying moorings.

The Sandpiper, with its various dredging accessories, has been constructed under the direction of Mr. Anthony G.

Lyster, M. Inst. C.E., Engineer-in-Chief to the Mersey Docks and Harbour Board, Liverpool, assisted by Messrs. H. H. West and Son, naval architects, Liverpool.

DEVELOPMENT OF THE FRENCH AUTOMOBILE INDUSTRY.

No. III.*

THE six-cylinder engine figured prominently at the Salon, more in deference to the prevailing vogue than in the belief among French automobile engineers that it possesses any considerable advantages over the four-cylinder motor. The movement which has grown up in England in favour of six cylinders had necessarily to be followed by those French makers who do a large export trade, and, besides, the six-cylinder engine offered an attractive novelty in an exhibition which presented little else that was really new. Thus many leading firms, as well as several of lesser note, showed six-cylinder engines. The Italians, who never lose an opportunity of keeping abreast of the times, are beginning to adopt six cylinders, while the Cannstat Daimler Company built one or two of this type some months ago, although the pattern is not yet a standard. The French are showing themselves somewhat refractory to the six-cylinder engine. Several firms, it is true, exhibited chassis with these motors, such as Léon Bollée, Hotchkiss, and Vinot and Deguingand, but Panhard and Levassor, who last year produced a chassis with a six-cylinder engine, have not persevered in their effort to popularise the new type of motor. Years ago attempts were made to introduce eight-cylinder engines, and then certain makers fitted chassis with three and six cylinders, but all these experiments finally resulted in a return to the standard four-cylinder type, which French automobile engineers believe will remain a permanent pattern. The only advantages of the six cylinders are that they give a fairly constant turning force, and can be often started upon the switch. If it were possible by this means to suppress the variable speed gear the advantage would, of course, be very appreciable, but while the six-cylinder car can be driven with the throttle and ignition levers for most of the time the change speed cannot be dispensed with, although it is simplified. There would be a great deal to be said in favour of the six-cylinder engine if it could do much more than is being accomplished by the four-cylinder motor. The engine, of course, runs more smoothly, and the great reduction in the weight of the fly-wheel is a point in its favour, but by compensating for the deficiencies of the four-cylinder engine with a heavier fly-wheel it is possible to get almost the same results as regards variation of speed as with the six-cylinder motor. By dint of improving the details of the four-cylinder engine the results obtained are often remarkable. If a suitable clutch be employed a car of this type can be driven at almost any variation of speed without touching the change-speed lever, and it is because so much is being done in the way of obtaining flexibility with the standard type of mechanism that French automobile engineers refuse, as a rule, to admit that the six-cylinder engine will enjoy any considerable vogue in the future.

At the Paris Salon it cannot be said that French visitors were disposed to show any particular preference for the six-cylinder car over the standard type of chassis. It is true that many of them were sold to wealthy buyers, and makers have doubtless booked a fair number of orders for delivery during the year, but even rich customers hesitate to pay more for a car unless its advantages are manifest, and as they require large and commodious bodies they cannot obtain these on the six-cylinder chassis except at the expense of a very long frame. Again, the future of the automobile is certainly not in the direction of expensive cars. However wealthy a man may be, he is less inclined than formerly to pay fancy prices for cars of well-known makes when he can obtain something almost equally good from newer firms who have facilities for turning out first-class chassis. Makers who a few years ago were able to command almost any prices for their chassis, are now finding competition extremely severe. Reputations are constantly changing, and a firm which stands at the top one year may find itself superseded by a rival the next. Cars are now beginning to command prices representing their intrinsic value, which is, to a certain extent, measured by the reputation and standing of the firms manufacturing them. Fewer buyers now purchase cars simply for the sake of the name.

Of new engines offering any promise of success there was a smaller display than in any previous year. There was a remarkable dearth even of new motors of any kind. The inevitable rotary engine was represented by an exhibit that was no better than the scores of similar devices that have preceded it, and it is difficult to foreshadow any brilliant future for an alterno-rotary engine in which an oscillating motion is given to four pistons moving in cylinders forming the arc of a circle. The two-cycle engine was again represented by the Legros, which is at present the only practical type fitted to motor vehicles in France; and after working for two or three years, it must be admitted that this ingenious motor is superior to the many other two-cycle engines which have been fitted to motor cars in the past. A Legros car ran satisfactorily in the recent trials from Paris to Nice and back. There was another two-cycle engine in the Salon, but we do not believe that it has yet been tested, and we doubt whether it would run ten minutes without getting red-hot. For the moment the four-cylinder four-cycle engine reigns supreme. Even on small cars this type is often fitted.

As regards fuels, many experiments are being carried out in France and Germany with various combinations of chemicals and hydro-carbons, whereby extraordinary results are claimed to have been obtained, but so far their compositions have not been made known, nor have these fuels been put upon the market, from which it is to be assumed that with a high explosive or expansive force they must present serious inconveniences. The use of picric acid in petrol was suppressed some years ago for the same reasons. Nevertheless, this search after new fuels may possibly result in something being discovered that will increase the efficiency of the internal combustion engine. Meanwhile, it is regrettable that so little is being done in the way of employing alcohol and paraffin. Since the Minister of Agriculture abandoned his attempt to encourage the use of alcohol on finding that the sole impediment to the employment of this spirit lay in the excise duties, the alcohol propaganda has come to an end. The only practical result of this movement is that carburetted alcohol is used on the motor omnibuses in Paris, where the suppression of the octroi dues brings it down to slightly below the price of petrol. Being a safer fuel, it is obviously specially suited for public service vehicles. At the Salon there was no internal combustion engine for motor vehicles designed specially to run with paraffin, and it was disappointing to find that in the trials of paraffin engines for motor boats recently carried out by the French Minister of Marine, not one succeeded in fulfilling all the conditions laid down, the most difficult being the starting of the engine with paraffin when cold. As regards the employment of safer and cheaper fuels, therefore, scarcely anything has been done during the past year.

An examination of the cars at the Salon showed that the most serious problem which makers have to deal with is the fitting of a suitable clutch. They have apparently got the most they can expect out of the leather-faced cone clutch, which has been improved in various ways by the interposition of springs and the like between the male and female members. But such a clutch is lacking in the facilities for slipping which are required for easy engagement or when running through traffic, and while the cone clutch is still retained on a large proportion of cars the tendency is towards replacing it more and more with the metallic clutch, in which the slipping is obtained through the agency of oil. The internal expanding type of clutch has until recently been receiving most attention from French and German automobile engineers, but as this design of clutch either slips too much or becomes too fierce, a great deal of attention has been bestowed upon its improvement, principally in the way of increasing the friction surface and providing a means of bringing the surfaces together gradually. Mors employs a clutch composed of a steel band which closes on a drum fixed to the fly-wheel. Another system which enjoys a certain vogue is the replacing of the ordinary leather-faced cone with a metal cone and enclosing it in an oil-tight case. All these systems, however, are giving way in popularity to the multiple disc clutch, which was first adopted in Italy by F.I.A.T. and in France by Panhard and Levassor, both of whom employ flat discs. The F.I.A.T. practice has been adopted by nearly all the Italian makers, whose cars are greatly appreciated on account of their flexibility due to the slipping qualities of the plate clutch; and now that Panhard and Levassor have decided upon fitting the multiple disc clutch to all their cars, instead of, as formerly, merely to the high-powered vehicles, a large number of other French makers are adopting this principle of clutch. The use of flat plates in these clutches is not, however, without causing serious trouble, not the least being their liability to buckle as the result of excessive slipping or after long use, and there is also a difficulty incidental to declutching when the plates are stuck together with oil. All these various types of multiple disc clutches are the outcome of the clutch introduced by Dr. H. S. Hele-Shaw about four years ago, when he saw that the only means of overcoming the difficulty of ensuring sufficient adherence for the transmission of high powers, and of allowing ample slip without running the risk of destroying the plates, was to press them with a corrugation which, while making the plate extremely rigid, ensured a grip of the plates when fully engaged under a relatively low pressure. The Hele-Shaw clutch is one of the very few English inventions which have made their mark upon the French automobile industry. It has been fitted to all the motor omnibuses running in Paris, and is being increasingly employed both for industrial and pleasure vehicles.

* No. II. appeared December 21st.

AERIAL ROPE-WAY IN ARGENTINA.

AT the foot of the Andes, to the north of Chilecito, the most westerly point of the Argentine Railways, are the valuable gold, silver, iron, and copper mines of Famatina, which have hitherto been practically inaccessible. This wild mining district, covering about 154 square miles (= 400 square kilometres), lies in 29 deg. S. latitude and between 68 deg. and 69 deg. W. longitude. The most important mines, at Upulungos, are from 15,400ft. to 16,400ft. above sea level, and about 4000 tons of rich ore have been annually brought down by carriers and mules to Chilecito, 3600ft. high. The climatic variations present great difficulties in working these mines. Chilecito has a tropical climate, while the mean winter temperature at Upulungos ranges from 0 deg. Fah. to 4 deg. Fah. below zero. The rarefied air impedes work at such high altitudes, and the district is also practically waterless and without wood. Owing to these obstacles, the mines could not be efficiently opened up, although they were known to contain, in places, 38 per cent. of copper and 3 per cent. silver.

After the opening of the railway to Chilecito, the mines were acquired by an English company, the Argentine Government undertaking to connect them with the railhead. This was only possible by means of an aërial rope-way, which has been built by Bleichert, of Leipzig. The line is in duplicate. There are two wire ropes, a main carrying rope and a guide rope beneath it, or four ropes in all for the up and down lines. The main rope is fixed, and extends from station to station, supported on trellis girders at intervals. The cars hang from it, and run along it on rollers mounted above them. The guide rope is always in motion. The maximum load is 40 tons on the down and 20 tons on the up journey. Part of the momentum of the descending cars is utilised, as in an ordinary funicular railway, for the ascending cars, but this is supplemented in the lower levels. Each car load is 1100 lb. of ore, or 1500 lb. including the car. The speed of descent is 8·2ft. per second—say, 500ft. per minute—and the cars follow at intervals of 45 seconds and distances of 369ft. The main rope is anchored at each station in the same way as the cable of a suspension bridge, and the cars are transferred by hand from one rope to the next. The guide ropes also pass only from one to the following station. The cars are coupled to each rope in succession by the Bleichert automatic coupling.

The line is divided into eight sections, with seven stations between Chilecito and Upulungos. The total distance is 21¼ miles, and difference of level 11,500ft. The distance between the separate stations varies from 5¼ miles to 1½ miles, and the gradients generally from 5 per cent. to 30 per cent., occasionally attaining 1 in 1. The copper-smelting works are at Chilecito, where the descending cars are run on to an automatic weighbridge, checked, and discharged into hoppers. Between the stations, at distances of about 1½ miles, the ropes are supported on iron girders, some of which have stretchers or braces, to maintain the due tension of the ropes. At several stations there are sidings and small steam engines and boilers for driving and starting the cars. From the fourth to the fifth station the line is carried over seven precipices on girders 160ft. high, then passes through a tunnel 1000ft. long, 14·7ft. wide, and 13ft. high, and spans an abyss in lengths of 840ft. and 1770ft. The distance is less than a mile between the next two stations, and the gradient 29 per cent. The seventh station is 13,000ft. above sea level; the difference of level between it and the station below it is 2200ft. in 1½ miles, giving a gradient of 30 per cent. In these upper sections there are spans from 2000ft. to 3000ft. across. The wire rope is replaced by rails through the tunnel and over the rounded top of a mountain.

Iron is chiefly used in the construction of the line. There are 275 trellis girders, varying in height from 10ft. to 160ft.; the span of the rope between them is from 328ft. to 3000ft. The main bearing rope is of two kinds. Where the load is not excessive a hollow spiral wire rope is used, of 95·25 tons per square inch breaking strength (= 150 kilos.). Diameter for the upper sections, where the gradients are steep, $1\frac{4}{10}$in. for the down rope, and $1\frac{1}{10}$in. for the up, and in the lower sections $1\frac{3}{10}$in. and 1in. respectively. Where the span is wide, and the load great, a solid wire rope of the same diameter is employed. At nineteen places along the line the rope is either anchored or braced over the supporting girders. The guide rope, as it is sometimes exposed to a stress of 11,000 lb., is of cast steel, seven-tenths of an inch in diameter, and 114 tons per square inch breaking strength (= 180 kilos.). The factor of safety is 4·5. The excess of power generated in the different sections on the down journey is sometimes as much as 75 horse-power, which is absorbed by a brake.

The cars have a capacity of 10·6 cubic feet, and each holds half a ton of ore. Other cars carry provisions, stores, &c., and there is one passenger car seating four people. Water is sent up in tanks slung on to the line. The main ropes are lubricated from a small car mounted on rollers, and containing a rotary oil pump and an oil vessel. This is sent along the line, the rotation of the wheels actuates the pump, and a jet of oil is distributed by a brush on to the rope. The guide rope is lubricated in the stations, where it passes over a pulley, the lower part of which dips in a bath of oil or varnish. All the stations are connected by telephone.

Much difficulty was experienced in making the line, which was built up from below, section by section. As almost everything had to be carried up by mules, all the machinery, material, &c., were divided into loads weighing 330 lb. (= 150 kilos.) Nearly 1000 mules were used for this work. Heavier pieces up to two tons were brought up by an army of carriers. The main ropes, weighing about 6¾ lb. per foot, were in lengths of 650ft. to 1000ft., with a total weight of about three tons. These were unwound, separated into coils without breaking them, and each length was carried by from sixty to 300 men. As the line progressed, the ropes were sent forward by attaching them to the cars.

The rope-way, on which 1200 workmen were employed, was begun in October, 1903, and completed in December, 1904. The cost of construction varied naturally with the height at which the work was carried out. At an elevation of 14,000ft. it was about 2s. per foot (= 72 marks per metre), and the wages 4½d. per cubic foot. The pay of the European workmen varied from 6s. 4d. to 15s. per day, according to the nature of the work. The line is managed by the Argentine Government. There are 640 cars. They do not stop at the intermediate stations, but run through, being transferred from one rope to the next without change of speed. The total cost of transport with mule carriage was 50s. per ton, or about 2s. per ton-mile. By the new line, when the maximum delivery of 40 tons per hour is reached, it will be 5s. 3½d. per ton, or about 3d. per ton-mile.

THE DETROIT SUBMARINE TUNNEL.—Through trains of the several railways entering Detroit are ferried by large train-ferry steamers across the Detroit River, which is really a channel connecting Lakes Huron and Erie. Owing to the constant traffic and to the difficulties incident to fog and floating ice in winter, numerous schemes have been proposed for crossing the channel by a bridge or tunnel. The former have been strongly opposed by the shipping interests, and the low shores would necessitate long and costly inclined approaches for a high-level bridge. A tunnel has finally been decided upon and is now under contract. Instead of actually tunnelling through the material, however, a high-level tunnel will be formed by sinking steel tubes in sections. A deep trench will be excavated by dredgers and piles driven in this level with the bottom; steel beams or girders will be laid upon these, and gravel will be filled in level with the tops of the beams. Steel tubes in lengths of about 250ft. will be floated into position and sunk, the sections being put together with sleeves and bolted flanged joints and gaskets. Divers will see that the tubes have a proper bearing on the beams. A temporary wooden form or mould will be bolted to the reinforcing ribs of the tubes, and a complete casing of concrete will be filled in around them. The interior will also be lined with concrete and have a heavy concrete floor. When all the outside concreting is done the dredgers will fill in around and over the tunnel to the level of the bed of the channel. The work will be done by the Michigan Central Railway, under the direction of its engineers, but all the railways will pay a share of the expense. The trains will probably be handled by electric locomotives.

RAILWAY MATTERS.

GOODS traffic on the Ulukhanlu-Julfa Railway has been opened to the Persian frontier, says a *Times* telegram from Tiflis.

THE London County Council propose to proceed as soon as possible with the electrification of the tramway from Vauxhall to Brixton-road at a cost of £94,000, exclusive of buildings and cars.

THE railway accidents in the United States in October last included 21 collisions and 23 derailments, besides several other accidents. There were 77 persons killed and 120 persons injured, the worst accident accounting for 57 deaths alone.

THE Board of Trade have recently confirmed the Leek, Caldon Low, and Hartington Light Railways (Borrowing and Further Powers Amendment) Order, 1906, amending the Leek, Caldon Low, and Hartington Light Railways Order, 1898.

IN 1901 the Russian railways offered prizes for an international competition for the best automatic coupling device for railway wagons, but the *Bulletin Commercial* reports that not a single apparatus has been judged to be in accordance with all the conditions laid down in the competition.

ORDERS have been received in the London and North-Western Railway works at Crewe for twenty engines of a new type for excursion and goods traffic. They will have four-wheeled bogies and six-coupled driving wheels. They are intended principally for express goods traffic between London and Carlisle, and will be capable of attaining a speed of 60 miles per hour with a maximum load.

AT the eighth annual festival of the Scottish Engine Drivers' and Firemen's Friendly Society, held in Glasgow on the 21st inst., the chairman stated that last year on the Scottish railways 5,500,000 first-class and 110,000,000 third-class passengers were carried, and 53,000,000 tons of minerals and 13,000,000 tons of merchandise were moved. Of all the people carried over the Scottish railway system, not a single life was lost last year.

A BILL is being promoted by the London and North-Western Railway Company to compel all railway servants under twenty-eight to contribute to the pension fund 2½ per cent. per annum of their salaries, while the company will contribute a similar amount. Sixty is to be the retiring age, and the pension is to range between 22½ per cent. on average salary after ten years' contribution and 100 per cent. after forty-five years.

ON a large stretch of its own land at Hessle, near Hull, the North-Eastern Railway Company is now embarking upon a scheme for the establishment of large coal-wagon standage sidings. There will be five reception roads and thirty-six sidings, the whole accommodating no fewer than 2000 wagons. The site is practically level, and is distant 1½ miles from the Albert Dock, Hull, and about 6 miles from the new Joint Dock which is now being constructed at Hull.

THE American Master Mechanics' Association specifications for locomotive boiler tubes require that they be circular within two-tenths of an inch, and that lap-welded iron tubes be tested to an internal hydraulic pressure of 500 lb. per square inch, and seamless steel tubes to 1000 lb. These requirements accord with those of the American Boiler Manufacturers' Association. This provides a suitable test of strength against rupture, but the stresses to which such tubes are subjected in service are just the reverse of that employed to test them, since it is collapsing stresses imposed by external pressure that they must resist.

WE are informed that Mr. James C. Inglis, general manager of the Great Western Railway, has accepted the chairmanship of the board of management of the Railway Benevolent Institution, and Great Western officers, stationmasters, and others are making a special effort in aid of its funds. The institution, which depends largely upon public support, is established to provide for necessitous officers and servants in the United Kingdom, for their widows, and for the maintenance and education of orphan children. In a history now extending over nearly half a century the institution has disbursed £700,000 in the relief of 120,000 cases, and it has educated and maintained 1700 children.

IN the last two years one hundred and forty-nine complaints of unreasonable railway rates were made to the Board of Trade. Of these, according to a report on the subject just issued, forty-five were on the ground of the rates being unreasonable or excessive; eleven of higher rates being charged for shorter distances on the same line; twenty-five of disproportionate rates, or of higher rates being charged for distances not on the same line; thirteen of unreasonable increases; and fifty-two complaints were of a miscellaneous character. Proceedings taken by the Board of Trade resulted in forty-nine cases being amicably settled, thirty-three complaints were not proceeded with by the complainants, and in fifty-nine cases an amicable settlement could not be effected. In the remaining five cases the proceedings have not yet been completed.

ALL records for heavy locomotives will be surpassed when the Erie Railroad receives from the American Locomotive Company next April three Mallet compounds which have been ordered. This type of locomotive was first used in America on the Baltimore and Ohio, where the one engine in service has been working on mountain grades east of Pittsburg for about two years. While the results have been satisfactory as regards maintenance and cost of operation, it is significant, says the *Railroad Gazette*, that the Baltimore and Ohio has not ordered more locomotives of the same type. The Great Northern engines, which are the heaviest yet built, have a total weight of 355,000 lb., with 316,000 lb on the drivers, and a tractive effort of 71,600 lb. The locomotives for the Erie will weigh 410,000 lb., all carried on 16 driving-wheels divided into two groups of eight wheels each.

THE Canadian Northern is probably the most rapidly growing railway system in America, says the *Railroad Gazette*. Starting some seven years ago with a small mileage, it sub-leased from the province of Manitoba the Northern Pacific lines in that province, and has since, by rapid building, extended its mileage in direct operation to 2700 miles. At the same time in Eastern Canada short railroads have been acquired or built, and are now held by allied corporations. The plans of the Canadian Northern are most ambitious. Besides a line to Fort Churchill on Hudson's Bay, the first 100 miles of which are already under construction, a through line from the Atlantic seaboard to Nova Scotia and New Brunswick *vid* Quebec, Ottawa, Sudbury, Winnipeg, and Edmonton, to the eastern boundary of British Columbia, is indicated, with completion of one of the westernmost lines to the Pacific undoubtedly to follow.

THE satisfactory performance of the single-expansion steam locomotive becomes more apparent as facts derived from accurate tests accumulate. We have it on the authority of the *Railroad Gazette* that from being regarded as a wasteful machine, the American locomotive is now coming to be looked upon as a machine of high efficiency. It was shown by Purdue Laboratory tests a dozen years ago that when all conditions were exceptionally favourable, the steam consumption per indicated horse-power hour could be brought as low as 25 lb. Statements to this effect have since been confirmed by results of tests obtained by the Pennsylvania Railroad at St. Louis involving a number of different locomotives. The report of these tests shows that a simple locomotive will operate on no more than 23·7 lb of saturated steam per horse-power per hour. Experience with American engines in this country cannot be said to have been so favourable.

NOTES AND MEMORANDA.

THE total receipts of the United States Patent-office for the past year from all sources amounted to £362,259; and the total expenditures were £311,629, leaving a surplus of receipts over expenditures of over £50,000, which surplus was turned into the Treasury.

IN preparing coal for use in a boiler it has been proved by experiment that the quantity of extremely fine dust through a 100-mesh screen is almost three times as much in unwashed as with the washed coal. This fact is of much importance, as the presence of fine dust has a great influence on the burning of the fuel.

THE United States naval engineers are to conduct at Annapolis tests of new inventions to determine their value for naval use. Among these, says the *Army and Navy Journal*, is the steam turbine, a model of which has been imported from England. It will be tested in comparison with the machinery now in use on shipboard.

THE electrolytic refining of copper has been greatly improved during the last decade, and is now in very common use. In 1892 the output of electrolytic copper was about 25,000 tons; three years later it was 87,000 tons, while in 1898 the output was estimated at 157,000 tons, and for 1902 was about 250,000 tons, a gain of tenfold in ten years.

AT the present time St. Louis has 983 manufacturing concerns and other plants that are using smoke-consuming devices, the character of which is as follows:—550 steam jet and air blast, 264 down-draught furnaces, 50 fire-brick arches, 19 automatic stokers, 74 have changed to electric power, 26 burning smokeless fuel. These plants contain from one to 30 boilers each.

THE friction of superheated steam within a pipe appears to be greater than the friction of saturated steam. It has been found economical to give the steam high velocity because of the relatively low radiation loss, and, though the actual drop in pressure is relatively larger, it may not be a mistake to submit to the loss of pressure from the boiler in order to avoid radiation losses from the pipe system.

AT the present moment there are between 1500 and 2000 motor cars in private use in Australia, and the number is rapidly increasing, garages having become established in most of the cities and large townships. The retail prices most in favour range from £150 to £250, the main object of purchasers being to secure a strong and powerful vehicle capable of great speed. The lower-priced motor cars command a good sale for business purposes in the rural districts.

THE memorandum prepared by the Labour Department of the Board of Trade for the *Board of Trade Labour Gazette* states that employment during November was good in all the principal trades, except the building trade and shipbuilding. The latter industry was affected by the present dispute on the Tees and by the recent Clyde dispute. There has been a considerable demand for pig iron, and blast-furnacemen are busy. Wages continued to advance in November. The increase in that month affected 160,000 workpeople to the extent of £3600 per week. As compared with a year ago, employment showed an improvement in most industries.

A SYSTEM of double filtration will be adopted at the Albany, N.Y., waterworks. Some very interesting experiments conducted by Mr. Greenalch, superintendent of the Bureau of Water, show that after twelve hours' sedimentation of the raw water, it has been feasible to treat it by preliminary filtration, without coagulants, at a rate of 85,000,000 gallons per twenty-four hours, and obtain an effluent that can be filtered satisfactorily by the present plant at the rate of 6,000,000 gallons per day. The number of bacteria in the final effluent with this double filtration has been found experimentally to be much less than that obtained now with single filtration, particularly during the winter months.

ACCORDING to the *Army and Navy Gazette*, the United States Naval Bureau of Ordnance has been experimenting with new types of batteries for electric firing of guns and for night sight lighting. Two types have been developed which have given very satisfactory results on shop tests. One consists of eight reserve dry cells, giving a voltage of 12 and a life of about 20 or 40 ampère hours. The other consists of four storage cells giving voltage of eight and a life of from 20 to 30 ampère hours. It is proposed to furnish batteries to vessels in groups of eight reserve dry cells or four storage cells, two groups being furnished for each gun; the two groups will be connected in series for firing, while one group will be employed for sight lighting.

THE report of the United States Commissioner of Patents on the business of the Patent-office for the fiscal year ended June 30th, 1906, shows that there were received during that year 55,619 applications for mechanical patents, 821 applications for design patents, 172 applications for re-issue, 1938 caveats, 10,888 applications for trade marks, 943 applications for labels, and 438 applications for prints. The number of patents granted, including re-issues and designs, was 31,837, and there were registered during the year 10,408 trade marks, 741 labels, and 354 prints. The number of patents which expired was 20,682, and 5193 applications which had been allowed were forfeited by operation of law for non-payment of the final fee.

AN example of the saving in room occasioned by the use of steam turbines is the case of the Kent-avenue power station of the Brooklyn Rapid Transit Company. According to the *Iron Age*, the 5500-kilowatt turbo-generator installed there takes up in itself a much smaller space than would be required for a reciprocating unit of similar capacity. Not only this, but the decrease in the necessary size of foundations is noteworthy. The machine is supported upon concrete piers about 3ft. square, upon which rest steel and concrete girders, to which the machine is bolted. The condenser is directly beneath the low-pressure end, and the room available around and between the piers gives sufficient space for all the auxiliaries, without encroaching at all upon the main floor.

THE tenacity with which the American motor car builders adhere to the air-cooled explosion engine is remarkable. In an account of a motor car show in New York, the *Scientific American* states that the air-cooled type of engine seems to maintain its popularity; and judging from the results obtained during the year in the various endurance trials, this type is capable of showing as high and even higher economy, at least in the more moderate powered cars, as the water-cooled engines. The type was tested severely in the recent Vanderbilt cup and elimination races, where one maker, using a positive feed of air through casings enclosing the cylinders, entered three cars each of 110 horse-power. The failure of these cars is said to have been due entirely to structural defects.

THE large new municipal generating station at Johannesburg, which is to supply tramways, lighting and power over an area of nearly 100 square miles, is now approaching completion. Producer gas is used with gas engines of respectively 1000 horse-power and 2000 horse-power. There have been some difficulties and a good deal of delay in getting this plant started. The usual starting difficulties of any new station have been accentuated by local conditions, by distance from headquarters, by the loss of a shipload of material at sea, and by the unfortunate death of the contractor's chief engineer. The *Electrician* understands that there has been no trouble that is not of the nature of a starting trouble of a purely temporary kind, and there is every reason to believe that on the completion of the work the results will be quite satisfactory from every point of view.

MISCELLANEA.

A DISPUTE between the workers and masters at Swansea Docks, which looked like becoming general, was amicably settled by an advance of wages last Saturday.

THE Finnish authorities have just received permission to order an ice-breaker at a cost of £34,000, and on the lines of the Yermak, which was designed by Admiral Makharoff.

THE antimony mines of Corsica are now being worked again, but it will be some time before any important quantity of ore is produced. The production in 1904 was 128 tons, all of which was from the Meria mine.

THE Harbour and Navigation Committee of the Colchester Town Council have had submitted to them a barrage scheme for the river Colne, and it has been decided to hold a special meeting to consider the proposal.

THE women workers in the chain-making industry at Cradley Heath, Staffordshire, have formed a union. The women number between 800 and 1000 out of upwards of 5000 hands, and their wages were about 6s. per week. Next year a demand for higher pay is to be made.

THE steel in the big wheel now being taken down at Earl's Court is being sent to South Wales, and, mixed with pig iron and iron ore, will be converted into Siemens steel bars for tin-plate making. Biscuit, tobacco, and mustard tins will be manufactured from these. The steel of the warship Montagu will undergo the same fate.

IN the French Senate last week M. Thomson, the Minister of Marine, said that the six new ironclads asked for were an indispensable minimum if they were to fill up the gaps that would be caused in the fleet by obsolete or inadequate vessels. On the advice of the Technical Commission sent to England, the Government had decided to adopt turbine engines for half the new vessels.

DURING the last few years a sum of nearly £1000 has been collected in Bury wherewith to provide a memorial to found scholarships in memory of the late John Kay, the inventor of the fly shuttle. A generous offer has now been anonymously made to defray the whole cost of a memorial, to be placed on the site of the old market, provided that the sum already collected be used entirely for the founding of scholarships.

AT their last meeting the Manchester City Gas Committee resolved to recommend the Council to apply for sanction to borrow £300,000 for extension purposes. The sum of £100,000 is needed for the construction of a new holder at the Bradford-road works, already the largest in the city, and among the biggest in the whole kingdom. The new holder will be able to contain 10 million cubic feet of gas. A sum of £50,000 is required for the completion of the retort house at Gaythorn.

A SAD electrical accident took place at Hamilton, on the 21st inst., whereby Harold Weston, foreman electrician in the employment of the Westinghouse Electrical Manufacturing Company (Limited), lost his life. He was employed in the Burnbank switch-house of the Clyde Valley Electrical Supply Company, and it is supposed he had lifted a live wire, and his head coming into contact with a copper switch, a current was sent through his body killing him instantaneously. His scalp was burned to the bone, and one of his arms was also severely burned.

THE Estates Committee of the Felixstowe Urban District Council have sent particulars of their experience to the Royal Commission on Sea Coast Erosion with the following comments:—Uniformity in system of sea coast defence is impossible of attainment; every portion of the coast must be separately treated according to its configuration and situation; local knowledge and local circumstances must be ascertained and studied before any course of action is decided upon. A protest was also raised against any general scheme of taxation, which would bear unduly upon districts which have already provided defence works.

DEPOSITS of manganese ore having been discovered in the Helenendorf Colony of the land set apart by the Russian Government for the use of settlers in the Government of Yelisavetpol in Trans-Caucasia, the richer colonists called in English engineers to explore the deposits and to report upon them. The analysis has shown that the new ore surpasses all deposits hitherto brought to light. The colonists will transfer to an English company the right to exploit the ore on the payment of £10,625, with a royalty of one farthing for every pood of 36 lb. that is won from the deposits. A light railway is to be laid down to connect the colony with the outer world.

ACCORDING to the New York *Journal of Commerce*, the expenditure of 6,000,000 dols. for public works now under course of construction or of urgent necessity in Cuba, has been recommended by Lieutenant-Colonel Black, in a report which has been approved by the Governor of the Island. This sum is a portion of the 12,000,000 dols. provided for such purpose by the Cuban budget. The remainder of this amount, 6,000,000 dols., will not be expended before the completion of a further study of conditions, upon which a supplementary report is to be made. The projects authorised consist mainly of the extension of important highways, the completion of public buildings and improvements in hospitals.

FOR water supply and bridge terminals the Board of Estimate of New York City on November 23rd authorised the expenditure of £3,000,000. Of this £2,000,000 is to be utilised by the Board of Water Supply for the contract awarded on December 4th for the construction of the first 11 miles of new aqueduct which will be built in connection with the Catskill water project. For the purchase of land approaches to the new Manhattan Bridge, £1,000,000 was appropriated. The Board also ordered title taken within thirty days or by December 24th of enough land adjacent to the Brooklyn Bridge on the Manhattan side for an improved bridge terminal, work on which should commence within ninety days.

A NEW deposit of manganese which promises to be an important source of supply is being opened up in Mysore State, India. It is situated 20 miles north-west of Shimoga Station on the Southern Mahratta Railway, 340 miles from Mormugoa. The distance from the deposit to the railway is covered partly by ordinary road, but the four miles nearest the mine are in dense jungle, through which a rough road has been cut. The ground is now being surveyed for a branch line from the railway. The deposit was discovered in August, 1905. By the end of 1905 mining was in full swing, and between March and August of the current year 20,000 tons were shipped to the coast and 25,000 tons additional made ready for immediate shipment.

AN ice locomotive, propelled by steam engines and resting upon four large steel helices, one at each corner of the body, has been constructed and successfully tested upon Lake Calhoun, Minn. The *Iron Age* states that the helices are arranged with axes horizontal, being of right and left-hand pitch on the opposite sides. The outer edges of the coils are fashioned like skate blades in order to grip the ice. Each spiral is connected to a separate steam engine, this independent operation giving splendid control over the movements of the apparatus, which can be driven forwards, backwards, sideways, or at any desired oblique angle. The model tested is 22ft. long, weighs 4½ tons, has engines aggregating 42 horse-power, and uses steel screws 27in. in diameter. The steering is by means of two semicircular steel discs at each end of the body, operated by compressed air.

WORKS OF THE WESTERN ELECTRIC COMPANY OF AMERICA

(For description see page 645)

Fig. 8—EXTERIOR OF THE FOUNDRY

Fig. 9—INTERIOR OF THE MACHINE SHOP

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

ERRATUM.

In our issue of December 14th, page 598, paragraph four, line 10 for "a layer of pressed wood felt" read "a layer of pressed wool felt."

MEETINGS NEXT WEEK.

THE LEICESTER ASSOCIATION OF ENGINEERS.—Saturday, January 5th, at 7.30 p.m., in the Technical School. Ordinary meeting. Papers: "Taps and Dies," by Mr. C. L. Robinson. "Casting Shopwork," by Mr. T. S. Taylor. "Workshop Test Indicators," by Mr. E. T. Goodchild.

ROYAL INSTITUTION OF GREAT BRITAIN.—Tuesday, January 1st, Thursday, January 3rd, Saturday, January 5th, at 3 p.m. each day, at Albemarle-street, Piccadilly, W. Experimentally Illustrated Lectures on "Signalling to a Distance, from Primitive Man to Radio-telegraphy," by W. Duddell, M. Inst. E.E.

THE ENGINEER.

DECEMBER 28, 1906.

Syndicate Control of Steel Prices.

IT is probable that a wider circle than that directly represented by British iron and steel producers will be interested in the question as to how the syndicate control of production and prices is working out in the German iron and steel industry at the present time. Here we have a huge monopoly in the form of the German Steel Syndicate, which, having commenced with a regulated output of over 8,000,000 tons in 1904, has succeeded in increasing the quantity to considerably more than 10,000,000 tons by the end of 1906. The combination, it is well to remember, is in no sense a trust according to American pattern, inasmuch as each of the works belonging to it is a strictly independent company or firm, both from a financial and administrative point of view. The only part played by the thirty-seven constituent works of which the syndicate is now composed is to sell to the syndicate—their own creation as a company—the output allotted to them in ingots, billets, blooms, and sheet bars, and in heavy rails and shapes, all of which may be said to represent an annual turnover of 6,000,000 tons out of the total previously mentioned. All other manufactures, which constitute the balance of 4,000,000 tons, are disposed of by the works themselves at whatever prices they may choose to accept. The Steel Syndicate, which purchases the semi-finished steel rails and shapes, pays for them at prearranged prices, and places the products on the market at the highest rates obtainable. It will thus be seen that the principal object of the combination, as the managing committee has explained on more than one occasion, is to find employment for the constituents, and it has been remarkably successful in doing so, judging from the increasing volume of business transacted down to the present time. There is no question of, or necessity for, the syndicate to attempt to earn a dividend for itself. On the contrary, all that the combination has to do is to negotiate orders and secure the completion of deliveries, and, after defraying the administrative expenses of the large organisation maintained, any surplus is available for division, over and above the pre-arranged purchase prices, among the associated works in proportion to their tonnage allotments of the particular classes of steel concerned—that is, semi-finished, rails and shapes.

The question of the surplus has played a prominent part during a large portion of the year 1906. It appears from the combination's tabular list of prices that the Syndicate pays to the works 65s. per ton for ingots, and 71s. for roughed down ingots, so that these rates would make billets 78s. 6d., and sheet bars 81s. per ton; and the purchase price for shapes ranges from 88s. to 90s., according to the section, and that for heavy rails is 90s. per ton. Now, although these prices are highly advantageous to the steel works, they have been largely added to during 1906 by the considerable surplus realised by the Steel Syndicate, owing to the upward movement due to the high period of prosperity in the iron and steel trades of the world; and as the sale prices for contracts now running, both in Germany and for export, are from 25s. to 35s. per ton above the purchase rates given above, it will be readily understood that a further increase in the surplus is in prospect for the period covered by these particular contracts. If, however, we take into consideration the first six months of the Syndicate's financial year 1906-7, that is, from April to September inclusive, we find that the sales amounted to 2,875,000 tons of the three classes which are price-controlled. The managing committee had arranged to give out of the surplus a bonus of 2s. per ton for the first three months and of 6s. per ton for the second three months. It has now been discovered that the surplus is greater than had been expected, and the bonus has been raised to 8s. per ton for the whole of the six months, and has also been fixed at the same rate for the third quarter which has just now been brought to a close. The bonus for the half year alone on the tonnage already cited works out at £1,150,000—a result attained on orders at considerably lower sale prices than those prevailing at the present time. This is a very handsome division of profits, in addition to those derived by the works from the list rates fixed as payable to them by the Syndicate under the existing agreement, and having regard to the higher sale prices now in force, it would seem that the bonus for the second half of the financial year should be still greater than that in question.

The financial success of the German Steel Syndicate, whose activity in Great Britain has not been experienced so keenly in recent months in consequence of the large inland consumption in the Fatherland, has now been established beyond a doubt from the point of view of a gigantic sales organisation for its constituent works in so far as concerns semi-finished steel, rails and shapes; but it has so far been impossible to induce the producers to agree to the price regulation of the other manufactures whose output only is controlled. It is, of course, upon the entire individual turnover that the works themselves base their prosperity, and they find the freedom to dispose of a certain amount of production unfettered by fixed prices to be a convenient means of working on a very economical basis as well as of securing additional profits. This fact is reflected in the higher dividends paid by most of the companies in the past financial year, and which promise to be even still more favourable for the current year, upon which many of them embarked a few months ago. In the circumstances, everything tends to show the probability of the renewal of the Steel Syndicate on the expiration of the present agreement at the end of next June. The policy of bluff is taking a leading position in the negotiations which have been proceeding for several months past in connection with the proposed prolongation of the Syndicate. Most of the constituents have made large extensions of their plant, and they nearly all demand the grant of a higher tonnage allotment than they already possess; but no one is disposed to give way to any of the others. The same tactics were pursued in 1903 and 1904 before the Syndicate was first formed, and they were continued right down to the last day. Yet the combination was brought into existence, and several other works were subsequently included within its scope. Having regard to the benefits conferred by the Syndicate on German industry down to the present time, it is highly probable that the organisation will be renewed, although it may be again deferred until the last moment. It is a contingency which British iron and steel producers must be prepared to face; but it will not be a pleasant one when an unfortunate turn in the present favourable course of trade takes place, owing to the large increase in the productive capacity of Germany in the past year or two.

The Future of the Machine Tool.

WE read with surprise in an esteemed Transatlantic contemporary that American engineers are expressing doubts about the value of the highly complicated machine tools which they have been purchasing for some years past. There is, we are told, a change of opinion, and managers are beginning to repent them of the rapidity with which they have adopted new models, and even urged upon the makers the desirability of introducing improvement upon improvement, till a degree of complication has been reached which is hardly balanced by the advantages accompanying it. To sum up the question, our contemporary asks:—"Has the machine tool builder gone too far or too rapidly in changing his tools; has his design been too radically altered; has he given his machines too great a complication of mechanism; will his latest models work out as an actual advantage in the works of his customer as compared to the tools he used to build?" Such questions as these were familiar some years ago in this country, but that they should now be raised in America, the very stronghold of the complex labour-saving machine tool, astonishes us.

We are even more surprised when we learn that American machine tool builders acquiesce in the contention that the more recent machines with "all modern improvements" are no better than their less elaborate predecessors, and that, "as a consequence, simplified forms of the latest type of machinery may be expected to constitute an important factor in the trade of the near future."

Now-a-days, what is done on one side of the Atlantic this week will be done on the other next week, and if the fashion is really about to change, and the purchasers on the far side are going to ask for simpler machines, our tool makers on this side will have sooner or later to revise their designs. It will come to us with less effort than to the Americans, for in this country there has always been a strong feeling that the degree of automaticity was exceeding profitable bounds, and that the multiplication of mechanism which had arisen through the progressive demands of purchasers were undesirable. For ourselves, we have always held that the conditions of the case must influence the decision. It is fruitless to say that what is best for one works must be best for another, even though both establishments be engaged on precisely similar work. A familiar example of this is found when we have two works making, say, traction engines, one seated in the centre of a great manufacturing town where wages rule high and boy labour is dear, the other situated in a country town with low adult wages and plenty of boy workers satisfied if they earn five or six shillings a week. To put an elaborate and expensive fully automatic machine into such a works as the latter is to throw away its virtues. It is in the big manufacturing districts that it has its chance. But even there the circumstances of its use must be taken into consideration. Long prices have to be paid for quick-change gears for feed and speed, and it is difficult not to feel in some cases that the amount of time saved by their use hardly compensates for the capital outlay. Unless the work that is likely to come to a machine require sfrequent changes of feed and speed, then, it is contended by a great many people, that the old cone wheel meets the requirements of the case. Here, again, no general statement of the kind can be made with any degree of accuracy. Consider alone the effect of the use of high-speed steels. Its requirements have made the use of a positive feed almost imperative, and the necessity for using such an expensive material to the best advantage requires that a fuller range of feeds than can be conveniently given by a cone should be readily accessible. Furthermore, the power that even comparatively small machines now consume requires heavy belting and high speed, both of which enforce the advantage of driving on to a single pulley and effecting the speed changes through gearing, the belt never being moved. Or, again, the effect of independent electric driving must be borne in mind. To drive direct from a cone pulley on the end of a motor spindle is in very few cases practicable, for the simple reason that even the smallest economical step of the cone gives a very high belt velocity, and larger steps are hardly tolerable. Hence the single broad belt suits electric drive admirably. All things of this kind must be considered before we can say whether a particular machine is unnecessarily complicated or not, and we think that if a mistake has been made by the Americans it is in the advocacy of highly specialised tools, without sufficient consideration of the circumstances under which they are to be employed.

An interesting point which presents itself is the nature of the promised simplifications. What form will they take? Shall we be invited to go back to the machine of ten years ago, or only to that of two or three? It is suggested in the article we are discussing that the user will still want the advantages he gets from the most recent machines, but that he will desire to see them reached in a simpler way. We presume a fair example of what is meant would be that of a change-speed gear in which one change—say a two-to-one—is made by shifting the belt, whilst three or four divisions for each belt speed are given by gearing. A return to such simplicity as that would, we believe, be found generally acceptable. It is in the milling machine that change-speed gears have been in some cases carried to excess, with the result that, for the sake of one or two changes at a useful part of the scale, wholly useless speeds have been provided at other parts, and on both sides of the Atlantic, we fancy, simpler designs would be welcomed. Unfortunately, this sort of items in machine tools is valuable for market purposes. Many things have been put into machine tools, and into other machinery for the matter of that, simply with a view to going "one better" than a competitor. They provide something on which the salesman can enlarge. That such things are frequently useful and valuable cannot for a moment be denied; but, apparently, the purchasers in America have now come to the decision that they are not necessities.

The Productive Efficiency of Steel Works.

A PAPER was recently read by Mr. James Waite, of Redcar, before the Cleveland Institution of Engineers, which is full of interest not only for steel makers, but for manufacturing engineers in general. Mr. Waite said very little about details, a great deal about principles; and these principles have a far larger application than the title of the paper, "The Productive Efficiency of Steel Works," implies. The paper has been very carefully written. It is not easy, indeed, to find any argument or even sentence in it open to serious criticism. Its reasoning can be followed without trouble, and the proper deductions drawn from it without much mental effort. The general theory advanced is, simply, that all the departments of a steel works should be competent to work together at the same pace, so that no delays, stoppages, or checks in the work of production shall take place. Interruptions Mr. Waite classes under the head of "friction," and the duty of competent managers consists largely in reducing friction to the lowest limit, or eliminating it altogether. A steel works is a vast mechanism, into one end of which go iron ore and coal and lime, while out of the other come plates and bars and finished steel. "Fantastic though this may appear," says Mr. Waite," "yet it is a fact that a steel works is but a huge machine for the production of sections, rails, or plates, and each department and each detail is in itself but a link in that great machine, and should therefore be treated as a part, and not as an independent unit, if uniform efficiency is to be obtained." Most of our readers will admit, we think, that this is true, *mutatis mutandis*, of all engineering works.

Mr. Waite begins with the blast furnaces. On them depends every department for the raw material. If they cannot supply enough to keep the steel furnaces and rolling mills going, then a loss will be incurred. But this does not represent the actual measure of efficiency. We must not estimate that by what goes into the works, but by the saleable material that comes out of it. The primary asset in steel works is the theoretical capacity of the finishing mill. "The maximum tonnage obtainable by the mill per shift, per day, or per week, should be taken as a working basis, with due allowance for roll-changing, but regardless of choking up the delivery in front." This is one of the few points on which we are not quite in accord with Mr. Waite. The statement is only true if the work ends with the finishing mill; indeed, it is easy enough to see that he admits a qualification. He assumes, of course, that no choking shall take place, and that the mill shall have fair play. But even with this allowance it may very well happen that straightening and shearing may not keep pace with the finishing mill and so block delivery. However, if the finishing mill is only taken as a standard with which every other department must keep pace, we are content. Let us suppose that shearing and straightening went on faster than the mills could supply rails or bars or plates. Mr. Waite would, we gather, reduce the shearing and straightening staffs. But would it not be better in any case, certainly better when pressing for delivery was the rule with customers, to augment the output of the mill? Again, as regards this mill, it is expedient that some definite standard of output should be decided upon. Mr. Waite told his hearers that in Germany or America an output of 2500 tons per week must be set against about 1200 tons in a works which is not laid out to secure maximum efficiency. The way in which he demonstrates the evil influence of apparently small matters is very instructive. Thus, he shows that when the process is intermittent, time and money are wasted. A plate is rolled and dragged out on the floor and left to cool, probably on top of others. Mr. Waite is silent as to the fact that in this way much injury may be done to the plates by the unequal heating and cooling which they undergo. Then it is lifted when cool into a bogie and wheeled to the shears. Then it has to be taken to the weighing-machine, and thence to the stock floor. The shears only run at about half their true capacity, and regulate the output of the mill. The way out of the difficulty is to deliver on a train of live rolls, upon which a continuous stream of plates creeps slowly forward, each plate, while still hot, passing automatically through a set of straightening mangles. The mangles require no attention, and their upkeep is very slight, so that the cost of flattening the plates is quite a negligible quantity, whilst the total value in time-saving to the ship or bridge-builder or boilermaker must be enormous. The plates thus go straight to the shears, and are not handled at all.

We shall not attempt to follow Mr. Waite through all his advice concerning the details of steel production. It will serve a better purpose to apply some of his arguments to other branches of manufacture. The first point on which he insists is the keeping of a proper record of all the events of each day. "Every stoppage should be noted, together with its cause. If this were done systematically and thoroughly the manager would often be amazed at the constant repetition of 'no steam,' 'want of material," 'hot bank choked,' and at the appalling loss of time thereby caused at the end of twelve months." Again, let us note the following passage:—"Taking a mill with 1000 tons per week capacity, and running for 100 hours per week, we have a productive rate of 10 tons per hour, or one ton per six minutes. With material at £6 per ton this equals a turnover of £1 per minute. For every minute, therefore, which the mill stands idle this £1 turnover is irretrievably lost." In how many engineering works do we find that no department is ever kept idle by another? Do we never find the foundry waiting for the pattern makers, or the machine tools for the foundry? We hold that one of the first qualifications that a works manager should possess is the power of making all the departments keep step; and this can only be done by a man who looks ahead. Many undertakings fail only because those in control live from hand to mouth, and, hoping for the best, find at last that they have the worst confronting them.

In one sense steel works management is much more simple than that of an engineering works, because in the latter departments are more numerous and details of production less simple; but the general principles are just the same. Maximum efficiency can only be had when every department is continuously employed to the greatest profit. As a rule this means that every man and machine tool should be at work. Lathes and planers can "eat their own heads off." It is bad enough that they should stand idle for lack of orders. But there is something radically wrong if the shortcomings of another department often leave them with nothing to do. It is to be feared that in not a few works there is lack of balance, the output powers of different departments being, even under the best conditions of management, unequal. But none the less is there reason to believe that what Mr. Waite says about some steel works is equally true about some engineering shops.

The National Physical Laboratory.

On more than one occasion we have drawn attention to the affairs of the National Physical Laboratory, and have indicated certain phases of its activities which appear to us not calculated to aid its healthy progress, and to be likely to bring into discredit a body the sound conduct of whose affairs is essential to the attainment of many objects of public importance. Criticism, however just, is not always entirely welcome to those whose actions are examined, and when the doings of a public body are scrutinised, and, perhaps, condemned by the public press, it not unfrequently happens that the body under examination exhibits a disinclination towards a salutary discipline. It is, therefore, with great satisfaction that we chronicle the latest important step in the development of the Laboratory on lines harmonious with its constitution, and consonant with the national needs which it was created to fulfil.

It has been known for some time that the Treasury is desirous of ascertaining precisely what has been the recent trend of policy of the Executive Committee of the Laboratory, and of inquiring whether that policy has been well-advised and just. Although no official announcement has yet been made, it may be accepted as a fact that a committee will be appointed by the Treasury to consider the whole question on its merits. In connection with this intention, a passage in the address which Lord Rayleigh delivered in his capacity as President of the Royal Society is of considerable interest. Lord Rayleigh, in the first place, defines his position by saying: "Of the activities working under the Royal Society, the one with which I have been especially connected is the National Physical Laboratory." He proceeds: "A question of importance has arisen as to the performance at the Laboratory of tests, partaking of a routine character, on the physical and mechanical properties of specimens of material. To this objection has been taken on the ground of competition with the work of private establishments. In one of its aspects the question is financial. But the Executive Committee are of opinion that, even if the pecuniary loss were recouped, the efficiency of the Laboratory would suffer from the abandonment of this work. While

anything like unfair competition with private establishments should be avoided, the execution of tests is good practice for the staff, and tends to keep them in touch with the manufacturers, and with the practical problems which may demand examination. In view of the difference of opinion which has manifested itself, the Treasury has decided to appoint a small committee to inquire into the working of the Laboratory, with a special reference to this question." This remarkable pronouncement of the President of the Royal Society, who has been especially connected with the National Physical Laboratory, is worthy of the closest consideration. It assumes that the objection which has been taken to the conduct of the Executive Committee of the Laboratory is based on the fact that the Laboratory competes unfairly with private testing establishments. This assumption must be met by a direct contradiction. The fundamental objection to the recent policy of the Executive Committee is on the ground that in pursuing that policy the Laboratory is going outside the functions allotted to it by the Treasury Committee of 1898, and in so doing is acting contrary to its instructions, and to the detriment of its public usefulness. That in thus seeking to exceed the bounds imposed on it, it will compete unfairly with private establishments is only an aggravation of an offence the gravamen of which is the violation of its charter. But although this unfair competition is a secondary matter, it may be dealt with in passing. In Lord Rayleigh's presidential address it is said that the execution of routine tests of specimens of material is "good practice for the staff, and tends to keep them in touch with the manufacturers." In other words, the staff of the Laboratory is to acquire its training by the process known as "trying it on the dog." Whether manufacturers will embrace this cynical *rôle* is another story. Private considerations of this kind are matter merely for comment. They do not touch the kernel of the case, which is that the National Physical Laboratory has under its charter no concern with routine tests of the physical and mechanical properties of specimens of materials.

In order that the Treasury Committee which is to be appointed shall satisfy public needs in directing the National Physical Laboratory towards the proper performance of its duty, and in diverting its activities from ways that will lead it to disaster, two things are necessary. First, the terms of reference must be sufficiently wide to allow the Committee to consider the working of the Laboratory in relation to its constitution as defined by the Treasury Committee of 1898 which led to its establishment. The Laboratory has no powers or rights other than those defined by this document, and all its acts must be controlled thereby. In the second place, the Committee now to be appointed must be small, strong, and rigidly impartial. It has been rumoured with some persistence that some five names have been already suggested, and that of these three are intimately associated with the Laboratory itself. That such a committee could be appointed we refuse to believe. The conduct of the institution through its Executive Committee is to be adjudicated upon. To allow that body to be judge in its own cause by the instrument of a committee including any of its own members or any person associated with the Laboratory, would be something worse than an error. The scandal which would arise from the findings of a committee prejudiced by its constitution in favour of persons whose acts it has been summoned to examine, would obliterate its claim to authority. There is already a deep-seated and widespread distrust of the wisdom of the present policy of the Laboratory. In the unfortunate event of the inquiry now proposed being conducted by any but a tribunal whose impartiality is unimpeachable, that distrust will take a concrete shape. It would be a lamentable thing if the activities of a body which, in the intention of its originators, was to be of great and increasing use for public ends, were to be cut short by the withdrawal of support in cash and in kind which will be the sure and certain outcome of a want of public confidence.

Suction Producer Trials and the Indicator.

IN our issue of December 14th we dealt briefly with some of the more important features of the recent trials on suction gas producers carried out by the Royal Agricultural Society, and we have since reproduced Captain Sankey's report. Certain features connected with the Mathot diagrams and the tables are of sufficient interest and importance to warrant further discussion. The utility of the Mathot indicator and recorder can well be judged by these trials. The instrument resembles an ordinary high speed indicator, with the difference that it has the usual pencil-carrying arm extended both right and left, so that it can carry two pencils in place of one, and, in addition to giving the usual diagram, record the up-and-down motion of the indicator piston on a slowly rotating drum; each explosion and expansion is represented by one vertical line. Between consecutive explosions the drum rotates a fraction of an inch, so producing a series of vertical lines; if the engine cuts out for one or more strokes, the long lines are replaced by short ones, proportional to the pressures of compression. This effect is easily seen and understood on reference to the diagrams contained in the report. Primarily, the use of the instrument is that it forms an automatic record of the number of explosions per minute, and of the way in which the governing gear is working. Can it do more than this? Apparently it is thought that it can; but, as will be seen from the considerations which follow, it is doubtful whether a good case can be made out for any such claim. Fundamentally, there is the danger lest it should be forgotten that the limitations which apply to the utility of an ordinary indicator—and they are well known—apply also to this form of the instrument perhaps even more markedly. To focus attention on this point, reference is made to Captain Sankey's report, and in particular to the sentence which runs thus:—"It will be noticed in Fig. 10 that the maximum pressure after a miss is generally less than at other times; this effect was observed in all the other engines with the exception of the Railway and General engine, but more especially of the Dudbridge engine, in which there was a great increase in maximum pressure after each miss." This sentence should be read more than once, and its meaning realised. Put into other language, it means that both the "Railway and General" and "Dudbridge" engines differ from all the others in that they show an increase of pressure following a "miss" instead of a decrease. This kind of result strikes the reader's attention immediately, and appears the more important because the competing engines showed in many other particulars a marked degree of similarity. It is divergences of this kind that offer the most promising field for research with a view to mechanical improvements. Before any useful conclusions can be drawn, however, it is necessary to know whether the record is an indication of the state of the engine or of the indicator. Other things being equal, it might have been expected that after a "miss" the next explosion would be of a more, and not less, violent nature, seeing that the residue of burnt gases mixing with the incoming charge would form a less proportion of the whole than in normal working. The solution of this apparent mystery must take one of two forms, either that no such phenomena occur, or that they are unimportant, as being merely the differences of other more important factors; now the danger of calculating upon a basis of small differences is well known. As regards the first alternative, criticism could hardly be effective unless all the diagrams were examined; in the present case it is only possible to deal with those which are reproduced in the report, and from them it appears that it might with equal, or greater, justification be alleged that a "miss" commonly follows *after* a less intense explosion rather than precedes it. This result directs attention about equally to the engine and the recorder; but let it be assumed that the phenomenon is a real one, and even then it will be seen that the influences at work to mask any such effect are so great as to make it dangerous to draw any conclusion from the observation above quoted. Everyone is familiar with the pronounced ripple marks which occur at the head of an ordinary indicator diagram taken from a gas engine; they are recognised as being due to the natural periodicity of the instrument, and it is customary to allow for them by drawing a fair line through them. But how is any mean to be taken when compression, explosion, and expansion are all represented by the same vertical line, the height of which must depend on the phase of the rippling which happens to be best represented? We have mentioned why the explosion following a miss might be expected to be more intense rather than the contrary, although we do not forget that some reduction of the compression temperature is only to be expected when the hot piston has had the time interval of the missed cycle in which to cool down, a view which receives some support from the fact that the two exceptional engines had lower compression pressures. This is plausible, but we think the probable cause of these differences between engine and engine lies rather in the ignition arrangements. Our knowledge of the phenomenon of ignition, and of the method of controlling it so as to bring about the best results, has increased very rapidly of late years, owing to the use of motor cars, and it is apparent that the readings of such a type of instrument as the Mathot indicator must be very sensitive to advances or retardations of ignition. With a late ignition the pressure will not rise so high, as the gases will have had opportunity to expand before explosion; and although an indicator card might show much the same mean pressure, it is clear that the Mathot instrument would record much shorter lines. These considerations lead us to the conclusion that, welcome as the instrument is for certain measurements, it would be unfair to it to build, on its records, elaborate theories or deductions as to what is going on in that veritable chamber of mysteries, the cylinder of an internal combustion engine.

FIRE LOSSES IN THE UNITED STATES.

By F. W. FITZPATRICK.*

THIS is going to be unlike most of the matter submitted to English readers by Americans. Usually, in writing for such consumption, we are accused, and not altogether without justice, of a considerable degree of spread-eagleism. And, frankly, we do enjoy telling you of our boundless resources, our great wealth, the extent of our land, the excellence of our machines, our wondrous inventions and smartness generally. Here, on the contrary, I am going to indulge in some serious introspection, a confession of national stupidity, a recital of our youthful follies that have become sins of habit in what ought to be our respectable middle age. If you say you are astounded at our backwardness, our lack of judgment in what regards our own interest, it would be no more than we deserve and may act as a spur to us to do better in the future, to shake off the trammels of precedent and of bad habit. Meanwhile you, respected and aged as you are, may have committed some of the very sins of which we have been so guilty, and a recital of the punishments that have been a natural result of our criminal negligence may deter you from further acts or omissions that will, sure as fate, ultimately meet with similar chastisement.

In the early times our fathers built of wood, and only substantially enough to resist the immediate attacks of the elements. Our pioneers in the woods had neither the opportunity, material, nor ability to do otherwise. Clearings in the forest fast developed into considerable settlements, and these, in many cases, into great cities. Wood, until very recently, has been most plentiful and cheap. We followed in our fathers' footsteps, and kept on using it. Fires became common and serious. Seemingly it never occurred to our people that better building—fire prevention—was the proper caper, and they have simply gone ahead working on fire protection instead, and building about as badly as they could the while. When it becomes a question of fire, one's mind naturally reverts to water, beautiful fire apparatus, and wonderfully acrobatic men, rather than to the elimination of fuel for that fire. Cities vie with one another, not in how few fires they can have, but in how quickly and well the majority of their fires are extinguished. That there is a slip-up once in a while, when, spite of our splendid departments, we have a conflagration or a holocaust, does not seem to matter much; we buy a few more steam engines, write beautiful obituaries, and go along the even tenor of our silly ways. This competition has become keen; to a certain extent it is a fad with our cities, and the cost of maintenance is enormous. In salaries alone the fire departments cost us £28,000,000 a year; high-pressure water and fire apparatus bring the cost of our so-called "fire protection" to a total of over £60,000,000 a year.

There is really a premium offered upon poor construction. In San Francisco, for instance, the insurance companies made an exceptionally low rate, spite of the fact that the city was ridiculously wooden and the fire hazard enormous, simply because its fire department was so very excellent. Yet what did it avail? Think of the accidents, even barring earthquakes, that may happen in other cities and that could result in equally great disaster. The expenditure for fire departments is a gamble in protection and grows as our cities grow at an exceedingly lively ratio, though there is no reason for such *pro rata* increase. On the contrary, the richer a city becomes, the more buildings it has, the saner it ought to be and the more it ought to reduce its fire risks by strict building regulations and better construction, and consequently reduce its expenditure for so-called "protection."

By spurts we occasionally attempt to better conditions. After some great calamity—the Iroquois theatre, for instance—building departments become exceedingly active, and there is much revision of building laws, a scurry to enforce existing ones, and the people themselves talk much about better construction, but we are still deplorably far from possessing reasonably sane laws, let alone enjoying an ideal condition.

Our folly has led us into such a muddle that it will take generations, with even the best of building laws, to lessen the danger appreciably into which we have so fatuously placed ourselves. Think of it, the country over there are 11,500,000 buildings, valued at £3,000,000,000—Russia has as many, but valued only at £700,000,000; the United Kingdom has 7,100,000 buildings; France, 9,000,000; Germany, 6,000,000; Holland, 1,000,000. Of these there are probably not 4000 that are even moderately "fireproof," in that some attempt has been made to protect the steel structural parts at least with fireproof or incombustible material, and not twenty that are damagable less than 20 per cent. of their cost in a conflagration, while there is but one, the Board of Underwriters' Laboratory Building in Chicago, that can truthfully be said to be absolutely fireproof. Of the millions of our homes there are not 200 that would withstand a lively fire attack for even five minutes. And

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yet we prattle about being a super-intelligent people!

By a peculiar coincidence, we have been as silly in our handling of forests and of our other natural resources, as prodigal with them as we have been lax in handling the fire question. The result is that what seemed to be a possible timber supply for hundreds of years is fast disappearing, so that to-day with us to build well of thorough fireproof construction it costs initially but 10 or 12 per cent. more than what is called "ordinary" building. The repairs needed are fewer, the deterioration is much less, little or no insurance need be carried, the returns on investment are greater, and inside of five years' time the owner has actually saved money, and from then on the difference in profit on the two investments, the good way and the bad way, is growing immeasurably greater in favour of the former. That is the individual side of the matter. Now, as a community the profit and advantage of sound building are even greater. Yet we go on, most of us, in our same old slovenly ways, and, in a vain endeavour to recoup ourselves for what even we realise must be certain loss, we go into nothing short of a gamble with the insurance companies.

We have paid those companies £325,000,000 in premiums in ten years. In 1905 we paid them £39,000,000, and they gave us back in adjusted losses £19,000,000. Howbeit, some of our people are beginning to think. We find, for instance, the mayor of a Connecticut town, having probably read something about municipal ownership in England or Scotland, and noting that his city had been paying for years an average of £100,000 in premiums, and that during the same time the average of losses has been but £25,000, advocating that the municipality go into the insurance business; but that question is tabooed in the States. Of it more anon.

No country on earth builds as rapidly and as expensively as we do, and no country on earth needs to build so rapidly, for none destroys its buildings at the rate we do. Not even in Japan and China, the lands of bamboo and paper, are the fire losses as great, in sum, *pro rata* of population, or as numerous or in any way equal to the really indecent losses we indulge in. This year is a phenomenal building one; so far it has never been equalled. The total will probably reach £125,000,000. Of that vast sum there will be spent not over £15,000,000 in reasonably safe construction, and certainly not £2,000,000 in absolutely fireproof construction—ratios that are far from comforting and that proclaim very loudly that our so-called progress in building is somewhat of a figment of the imagination. We know what is good construction—no one knows better than we—but we do not apply the knowledge, and our people prefer to pay for frills and furbelows. We have evolved the skyscraper; our buildings are richly ornamented, and we use extravagantly most costly materials; the conveniences we have devised and installed are away ahead of anything you or the continental peoples have; our systems of heating, of ventilating, of lighting, of refrigerating, are unequalled; our plan arrangement is unexcelled; no one knows better than an American how to utilise every bit of ground, and how to get the most out of it; but, withal, we build too hastily and flimsily. And our fire losses have by rapid jumps reached the £40,000,000 mark per annum. But that is "normally." Our 1904 losses went up to nearly £50,000,000 on account of the Baltimore fire; San Francisco's fire assures that 1906 will show £100,000,000 loss, at least, and what guarantee have we that some other great disaster will not wipe out ten or twenty millions more? Have we not built so poorly that from now on we must expect that the abnormal year will be, not the one of great disasters, but the one when none occur? The cost of our fires constitutes a tax that is eight times greater than the similar *per capita* tax of all Europe.

The figures here quoted are official, taken from insurance reports, municipal department statistics, and building inspectors' notes. Yet there are many communities from which imperfect or no reports are received and many fires unrecorded. It is safe to assume, therefore, that those figures are minimum, and really do not represent our total loss. Realising that, and also that February, March, and April seem to be the months during which most fires occur, I went to considerable trouble and expense last year to secure data about absolutely every fire occurring during a period—ten days—chosen at random out of those three months. During those ten normal days 1315 fires occurred, totalling a loss of £2,960,000. On one day, when all the complicated machinery of getting these returns was in perfect working order—February 23rd, 1905—when I know that nothing escaped me in all the land, there were 165 fires, doing a damage of £403,000, so that our real fire loss is very much greater than what we have supposed it to be.

That was a very ordinary, let us call it a normal, day. But here is the other record, that of San Francisco's fire, that lasted three days and swept five square miles of territory, 500 city blocks, or about 25,000 buildings out of existence. It laid bare egregious stupidity on the part of the authorities, the architects and builders. The actual destruction of buildings means £65,000,000 wasted in smoke; £200,000,000 in business lost to the city and the country generally; £2,500,000 to clean up the *débris*; and £70,000,000 more and twenty years' time to put the city in even the condition that it was before! The sum of these figures represents the cost of that fire, to counterbalance which the people may receive the paltry sum of £24,500,000 from the insurance companies. Surely not a profitable gamble.

Merely by way of illustration of the imbecility of poor construction, it is well to note that had £2,000,000 more been spent originally in sane provisions against fire it would have reduced this loss at least £32,000,000—a pretty good interest on the investment. Or if the architects had had but sense enough to have spent even £120,000 more on the thirty-five so-called "fireproof" buildings, or, rather, shifted that sum from frivolous ornaments to necessary precautions—covering every particle of steel framing, for instance, with hollow fireproofing tile—they would have saved those buildings intact, buildings in which £1,800,000 or more destruction was wrought. Simpler still, had the precaution been taken of protecting the windows of those buildings with wired glass, at an additional expenditure of possibly £12,000, their interiors and contents would certainly have been saved.

We say that San Francisco was stupid simply because her stupidity has been uncovered, laid bare to our aftersight. True, she and New Orleans were at the very tail end of cities as regards excellence of construction, but nevertheless and notwithstanding, almost as appalling a catastrophe could happen in any one of at least 60 per cent. of our cities. A great conflagration need not necessarily be started by an earthquake. Can you not imagine a reservoir breaking at a moment when water is most needed for fire, or of a pumping station being destroyed at an inopportune time, or a hundred other accidents that would permit of a fire getting beyond human power to estop?

Build now as well as we can, it will take a generation's time to eliminate the possibility of these great conflagrations occurring. For the time being, the best we can do—and it behoves us to do it—in the way of fire protection is to build as nearly fire-proof as we can, and offer fire as little to burn as we know how. It requires no lengthy process of reasoning to realise that where there is no fuel there can be no fire, and where there is but little fuel there can be but little fire. Buildings can be well built—built so that even a conflagration cannot harm them. More than that, if sufficient intelligence is brought to bear on the matter, buildings can be so constructed at not much greater cost than that of the flimsiest fire-trap.

What people deem the excessive cost of fireproof construction is brought about by the fact that there is so much to burn all around that to be immune one has to take extraordinary precautions with his building. Did we all build properly, paradoxical as it may seem, there would be little occasion for absolutely fire-proof construction; to make the buildings incombustible would be all that is necessary.

Reverting again to poor San Francisco, that stricken city has shown that she has not profited over much by her severe lesson; her new building laws are but little better than the old; the suggestion we made to widen some of her streets, thus creating fire barriers, has been scouted at—ignored. She has not enlarged her fire limits and no period has been assigned to the temporariness of her very temporary buildings, and it is only a question of time when almost as terrible a catastrophe may befall her as the ordeal through which she has just passed. All this is done with a mistaken idea of economy. Even if each individual had to put 50 per cent. more into his building than he intended to, or reduced his ornamentation and frills to that extent in order to build properly, it would mean in the long run profit to himself and to the community. But many billions of property will yet have to be destroyed before we learn our lesson.

Quite incidentally—because life is cheap with us—we have gotten to the point where nearly 7000 lives are annually wiped out by fire, and every day in the year there are 36,000 lives directly exposed to destruction, people carried out of burning buildings, escaping to adjacent roofs, &c. &c., of whom quite a large per cent. are more or less injured.

New York averages "normally" 7800 fires a year; Chicago 4100. We burn up 3 theatres, 3 public halls, 12 churches, 10 schools, 2 hospitals, 2 asylums, 2 colleges, 6 apartment houses, 3 department stores, 2 gaols, 26 hotels, 140 flats and stores, and 1600 homes every "normal" week—a record of which we surely need not be proud.

In a most exhaustive examination of the results of that horrible fire at San Francisco we found nothing that was not perfectly known to fire experts before, nothing new for us to preach about; just the same old folly of using wood where it ought not to be used, and the same mistaken zeal in applying the term "absolutely fireproof" to buildings whose structural parts only were incombustible and protected. The standard of a perfect building remains just as it was before, and we can but reiterate our advice, our prayer, even though it be in but a wail in the desert.

The perfect building is the same here as it is with you or anywhere else. A building that is of incombustible materials is not necessarily fireproof; a building that is of fireproof materials, but not of fireproof design, is not fireproof; a building that is not of fireproof construction and design, except in part, is not fireproof; a building that is strictly, thoroughly fireproof, filled with combustible contents, may have a destructive fire in some one of its parts, but the building itself will not be wrecked or destroyed, and if the units are properly separated and protected, the floors absolutely isolated one from the other, the greater part of that building's contents is safe.

Let us summarise. The first essential of a good building is a good foundation. Where there is not a sufficiently hard bottom, I would use caissons and concrete piers, or reinforced concrete piles. If the exterior is to be masonry construction, I would use concrete or brick, but in any case faced with well-burned brick and terra-cotta trimmings. That some terra-cotta went all to pieces in San Francisco is neither here nor there, though used by some as an argument against the material; one might as well argue against railroads as the proper means of transportation, because through negligence or ignorance there have been serious accidents on some. It is the architect's business to see that the material comes up to the required standard. It must be patent to the most obtuse layman that, at least on narrow streets, or wherever exposed to external fire, granite, sand, and limestone, artificial stones and concrete, or stucco, are all bound to spall and to be damaged even beyond repair. The steel framing must be perfectly held together, and substantially; it must be braced and counter-braced; and, where quakes are possible, laterally tied and reinforced at the centre, and so that all movement be taken up in the elasticity of the steel and not in the racking and sheer of rivets. All the steel work must be thoroughly coated with cement and protected from fire with brick or hollow fireproof tile or a very thick body of good concrete. The floor construction and partitions should be of hollow fireproof tile or brick of narrow span, and well built with cement, and tied to the steel work. Where, in lieu of steel, reinforced concrete has to be used, it, in turn, has to be protected from fire. We hear a good deal of the fireproof qualities of concrete, but San Francisco's and every other fire have fully demonstrated, even if our good sense did not tell us so, that it is utter folly to call any material "fireproof" that loses 50 per cent. of its efficiency in 750 deg. of heat, when a most ordinary blaze is apt to develop from 1500 deg. to 2000 deg. We have seen beautiful laboratory tests that would seem to controvert that point, but the fact remains the same. The attractiveness to most architects of concrete construction lies in that very wide spans are possible, and that the work is cheap. It can only be cheap if cheaply done—I mean scamped. If two or three more inches of concrete were used than is really needed for strength, and all reinforcing members placed at least 2½in. from the surface, a considerable amount of deterioration or disintegration could take place before affecting the stability of the structure; but that adds greatly to the cost and to the weight, and people will not do it. Therefore, where merely as much concrete is used as is required for structural purposes, it must be treated as is the steel—protected from fire. The finished floors and interior trim of our model building should be of cement, or marble, or asbestos, not wood; so with the doors, they should be of metal or other incombustible material. Then, where there is the slightest danger from external fire, the windows should be protected with metal or asbestos sash and wired glass, and where danger is very great, double sashes of wired glass. Metal and other "automatic" shutters seldom work at the right time.

The interior of the building should be cut up into as small units as possible. Great expanses of floor are much desired by retailers, but the comparatively small unit is the only safe one. Elevator and stair shafts should be enclosed at every storey, and with doors at every floor that have to be opened whenever one passes. That, and that alone, secures immunity of storeys. Fittings and furniture should be metallic as much as possible. The main stairway should debouch directly to a street, and being the natural and daily means of ingress and egress to the building, it logically becomes the natural fire escape in case of real or imaginary danger. Every precaution should be taken so that incipient fires, that are bound to occur, can be successfully fought and restricted to the one little unit in which they originate. Fire appliances should be freely installed and employés trained in their use. A fire drill is never wasted time.

In such a building, and in such an one only, is there absolute immunity from destruction by fire. The tenants' property can only suffer from insignificant local blaze. Their interests are best safeguarded in such a structure, and, in turn, the owner has a permanent, non-damageable investment. Such a building is not an unattainable affair. To do all these things well entails skill on the part of the designer, true; but even the first cost of construction is surprisingly little more than that of the most flimsy affairs. The surprise, the astounding thing about it all, is that in this great and prosperous country of ours there are not twenty such buildings!

Pattern after us, if you wish, in the building of skyscrapers—and they are surely justified in your congested districts, where property is so immensely valuable—use our materials, install our systems of lighting, heating, ventilating, if desirable; introduce the hundred-and-one conveniences that are so common here though comparatively unknown elsewhere; use our methods of rapid construction, and make your buildings less ponderous and gloomy than you have been doing, lighter, gayer, as we do; but, in the name of all that's sensible, when it comes to assembling those things together, do it as we preach, and not as we have been guilty of doing nine hundred and ninety-nine thousand times out of a million!

ELECTRIFICATION OF AN AMERICAN RAILWAY.

THE Pennsylvania Railroad has recently converted to electric traction its line from Philadelphia to the sea-coast resort of Atlantic City—65 miles—with a 10-mile branch to Millville. The line is double and triple tracked, and has 85 lb. and 100 lb. rails. The traffic will comprise trains of three cars running at intervals of 15 minutes and attaining speeds of 60 miles an hour, the road being practically level. The power station has twelve Stirling water-tube boilers of 360 horse-power supplying steam at 175 lb. to three Curtis steam turbines carrying alternating current generators of 2000 kilowatts, 25-cycles, three-phase, 6600 volts. This current is stepped up to 33,000 volts for transmission to the sub-stations, where it is reduced to 430 volts, and then converted through rotary converters into 650 volt direct current, which is fed to the third-rail conductor. There are eight sub-stations. The transmission line is double, and 71 miles long. The poles are 45ft. long and 125ft. apart, with cross arms carrying insulators tested to 85,000 volts. The cable consists of six hard-drawn solid copper wires of No. 1 Brown and Sharp gauge. The third rail is of 100 lb. flange section, 26in. from, and 3¾in. higher than the track rail. It is protected by plank covering. On the Millville branch the overhead trolley system is used, the wire being 22ft. above the rails. Double-bogie carriages are used, 55ft. 6in. long, 9ft. 10in. wide, with the roof 13ft. 3in. above the rails, and the total weight is 47 tons. The motor bogies have 36in. wheels, and two 200 horse-power motors geared to both axles. The trailing bogies have 33in. wheels. The passenger cars seat 60 persons, and there are also mail, luggage, and parcels wagons, all fitted with motors.

DRIVING-WHEEL LATHE

NILES, BEMENT, AND POND COMPANY, NEW YORK, ENGINEERS

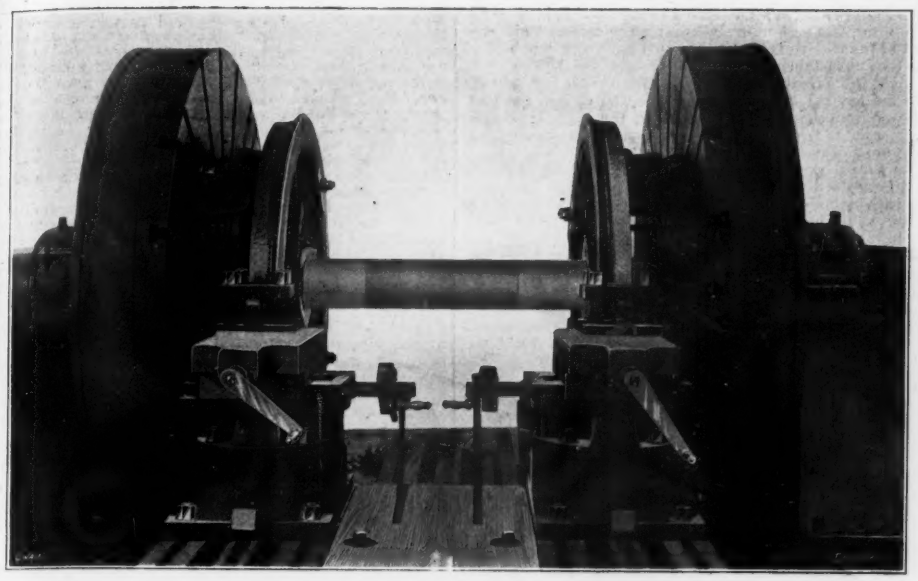


Fig. 1

DRIVING-WHEEL TIRE LATHE.

In locomotive repair work one of the most important operations is the turning up of worn driving-wheel tires, rapid and good work being required to avoid delay, while at the same time the waste of metal must be avoided. The use of cutting tools of modern high-speed steel in machine tools specially built to stand the strains of high speeds and deep cuts has greatly reduced the time formerly required for turning tires, while special tools are now frequently used for finishing off the work to a smooth burnished surface. In the accompanying illustrations Fig. 1 represents a heavy 90in. chucking lathe for driving-wheels, which has an average capacity of from six to ten pairs of tires per ten-hour day. The machine is driven by a 35 horse-power electric motor, with a Morse silent chain, and has a motor of 5 horse-power for traversing the head. The face plates are driven by internal gears, the pinions of which are driven by intermediate gears, thus increasing the speed of the main driving

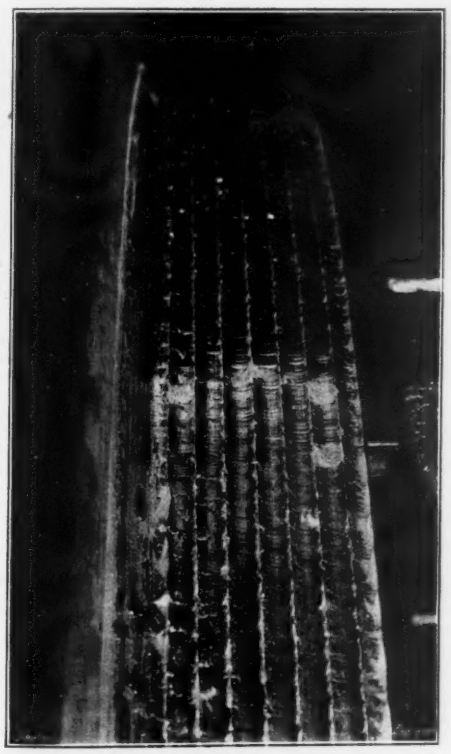


Fig. 2—TIRE AFTER ROUGHING CUT

shaft. As this shaft runs at three or four times the usual speed in such machines, and is also of larger diameter, its torsional strain is very much reduced, and it makes the drive of each face plate steady under the heaviest cuts. The face plates are 8ft. 6in. diameter and 6ft. 8in. apart, and the machine can take in wheels up to 7ft. diameter without changing the position of the carriages. The swing over the bed is 8ft. 8in. The driving dogs, which clamp the wheels to the face plates, hold the wheels rigidly by the rim, and enable the machine to run at the heaviest cuts and the highest speeds that the tool steel will stand without the vibrations that occur when the wheels are clamped by dogs that grip the spokes. All wheels except those having the main crank pins can be set in place without traversing the movable head. For the main driving wheels the head is traversed outward to clear the crank pins, and the wheels are then set in place, with the crank pins fitted to the holes in the face plates. The head is then traversed back into position. These powerful lathes are built by the Niles, Bement, and Pond Company, of New York, and are in use in a number of large railway shops. Cutting speeds of about 12ft. per minute are used, and the machine will take a full cut at $\frac{1}{4}$in. feed. The machines are designed for taking cuts $\frac{1}{2}$in. deep, $\frac{5}{16}$in. feed, with a cutting speed up to 30ft. per minute.

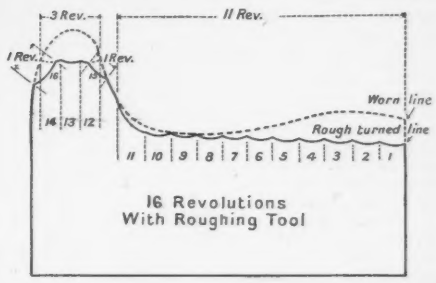
Fig. 3—MOUNTING A FLANGE TOOL

The weight is about 50 tons, and the machine must, of course, be securely anchored to a solid and heavy foundation.

In the new works of the Canadian Pacific Railway one of these machines has been doing excellent work, and while the actual speeds of finishing a pair of tires may have been exceeded in other works, it is to be borne in mind that this railway makes exclusive use of Krupp steel tires of great hardness. This machine can in a ten-hours day turn out five pairs of worn 7ft. driving-wheel tires, or six pairs of 4ft. tires; or in two such days it can turn out the twelve pairs of 4$\frac{3}{4}$ft. tires of three eight-coupled goods engines. On one occasion three pairs of 5ft. 9in. tires with flat spots were turned in six hours; a $\frac{5}{16}$in. cut with $\frac{1}{4}$in. feed had to be removed to clean up the hard flat or skidded spots, and at some points this necessitated turning off as much as $\frac{7}{16}$in. in depth. Three pairs of 5ft. 3in. tires, skidded, but not badly worn, have been turned in five hours, including the time required to set the machine.

With the older machines and tools the time required to turn a pair of 4ft. 9in. tires averaged 3 hours 20 minutes, as follows:—Twenty-four minutes to pick up tires from the floor and set them in the machine ready for the cut, 2 hours 45 minutes to machine them, 11 minutes to release the wheels and remove them from the machine to the floor. With the present machine and tools a pair of 5ft. 9in. tires can be turned in less than two hours, as shown by the following record for both flanged and blind tires, the former being 5$\frac{1}{2}$in. and the latter 6in. wide:—

	Flanged tire. Minutes.	Blind tire. Minutes.
1. Pick up tires from floor and set in machine ready for cut	11	11
2. Put roughing tools in and out and take roughing cut on tread	42	52
3. Put roughing tools in and out and rough out flange, both sides	22	—
4. Put finishing tools in and out and finish tread	10	15
5. Put finishiog tools in and out and finish inside bevel	—	14
6. Put finishing tools in and out and finish flange, both sides	13	—
7. Put finishing tools in and out and finish outside bevel	9	16
8. Loosen wheels and remove them from machine to floor	4	4
Total	111	112



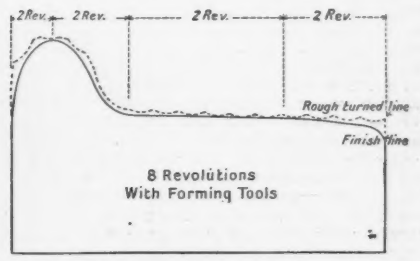


Fig. 5—DIAGRAM OF CUTS

These figures are not of a record or special run, but are equalled in regular daily work. Both pairs of wheels were from the same engine. The depth of cut was $\frac{3}{16}$in., and the feed $\frac{1}{4}$in. The cutting speed was 13ft. per minute, reduced in cutting hard spots. Five sets of roughing tools were required. If the tires had been softer, and the work could have been done with two sets of tools, as is often the case, the time would be reduced for both roughing and finishing. In turning a 49$\frac{1}{2}$in. tire, $\frac{3}{8}$in. depth of cut, $\frac{3}{32}$in. feed, and 11ft. per minute cutting speed, the maximum power developed was 27$\frac{1}{2}$ horse-power. With a 52in. tire, $\frac{5}{16}$in. cut, $\frac{3}{32}$in.

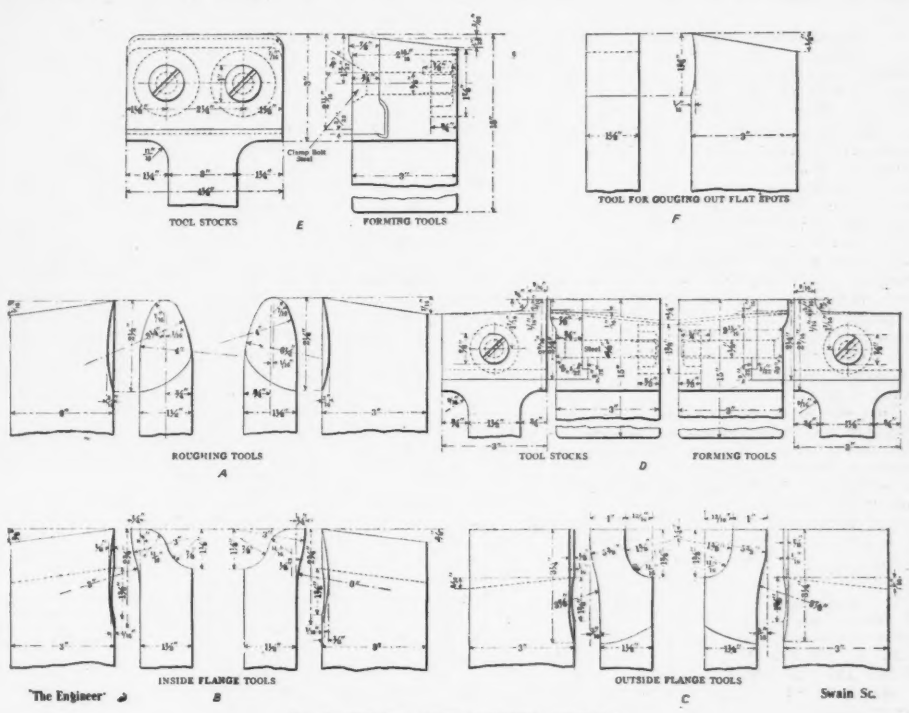


Fig. 4—SPECIAL TIRE TURNING TOOLS

feed, and 16ft. cutting speed, the power was 29 horse-power. No injury to the tire results, and the tools stand up to the work remarkably well.

Mention has been made of the use of special forming tools to give the wheels a hard smooth finish. Some of these are shown in Fig. 2. The roughing tools A are for roughing out the tread and flange; B is the tool for finishing the throat or fillet and the inside face of the flange; C is for scraping or finishing the outside or back of the flange; D is the tread-finishing tool for both flanged and blind tires; E is the taper or bevel tool, with radius for finishing either blind or flanged tires; F is a tool used to remove hard spots which cannot well be taken out with the roughing tool. With such a tool as that at F it is possible to get under the hard spot. This set of tools enables a tire to be turned and smooth finished very quickly. Fig. 3 is a view showing the operator handling the tool for finishing the inside of the flange. Two revolutions suffice for each of these finishing operations.

The tools are of air hardening steel, with a section of at least 1½in. by 3in. Fig. 2 shows the face of a tire after the roughing cut, the tool having been fed across the face in nine revolutions. The diagrams in Fig. 5 show how a tire can be finished in twenty-four revolutions, sixteen being for the roughing cut and eight for the finishing cut. This is very frequently done in twenty-two revolutions. A fair average time for putting in and chucking the wheels, with the operator, one helper, and the travelling crane man, is 12 minutes, but it is often done in less. About three minutes are required to take the wheels out of the lathe. The actual time for turning will be about 45 to 60 minutes, depending upon the character of the tire, the speed the tool steel will stand, and the general operating conditions of the shop. In the Canadian Pacific Railway Works the average cutting speed is 13ft. or 14ft. per minute, but this is, of course, reduced when hard spots are encountered. Even higher speeds may be used with softer tires. All roughing out of worn tires is done in one cut with an average feed of ¼in., and with this feed—if no hard spots are made and no tools changed—a blind tire 6½in. wide can be rough turned in 26 revolutions, or the tread of a flanged tire 5½in. wide in 16 revolutions.

The different operations are done in so short a time and under such conditions that all the operator's time is required at the machine, and the grinding of tools is assigned to an expert tool-grinder, who also sees to the dressing and tempering of the tools. The machine operator also has a man to assist in setting the machine for tires of different sizes and in placing and removing the wheels. Axles are inspected for cracks, &c., while in the lathe; the helper cleans the axle and paints it with a mixture of 1 lb. of white lead to 1 pint of lard oil, and should there be any cracks the strains on the axle while being turned will cause the oil to ooze out of the cracks and thus bring them to notice.

In a test made with one of these lathes at the West Albany Works of the New York Central and Hudson River Railroad, fifteen pairs of driving wheels 4ft. 2in. to 6ft. diameter were turned in 13 hours 24 minutes, or an average of 53·6 minutes per pair. The cutting speed varied from 8ft. 6in. to 14ft. per minute, most of the work being done at a speed of 12ft. 9in., with from 21 to 23 revolutions to complete the work on each wheel. The following table gives the results of another set of tests made at these works, in which ten pairs of tires were turned in 9 hours 6 minutes, or an average of 54·6 minutes per pair, including the placing and removal:—

Diameter of tire	Cutting speed.	Feed per revolution	Depth of cut.	Time of cutting.	Time of changing wheels.	To'al time.
in.	ft. per min	in.	in.	mins.	mins.	mins.
64	12¾	1/16	1/8	45	8	53
64	12¼	3/32	1/8	46	9	55
64	12½	1/16	1/8	44	10	54
64	11⅝	1/16	¼	43	9	52
64	12¼	1/16	1/8	42	8	50
64	10⅝	1/16	¼	50	8	58
64	8½	1/16	1/8	52	8	60
64	11	1/16	¼	47	9	56
79	14	1/16	¼	46	10	56
79	14	1/16	1/8	43	9	52
		Total	time	458	88	546

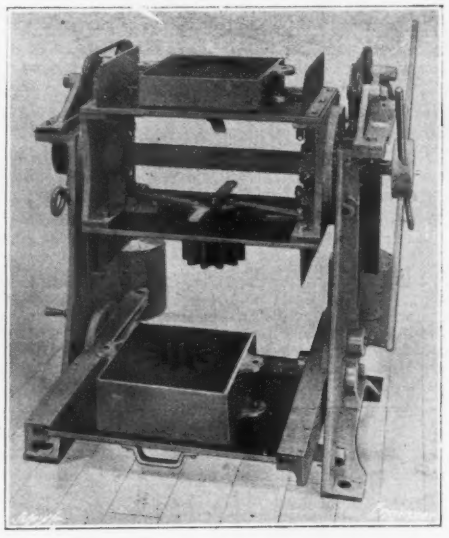
UNIVERSAL MOULDING MACHINE.

AN ingenious moulding machine has recently been designed and constructed by Thomas Middleton and Co., Limited, of Loman-street, Southwark, S.E. It is capable of dealing with a large variety of work, and appears to be a considerable time saver, even when odd jobs are carried out on it. For repetition work it is particularly useful. The makers claim for this machine (i.) that there is an accurate lift which prevents any breaking of the mould and consequent time lost in mending up; (ii.) that the boxes are perfectly registered when placed together; (iii.) that no rapping is required; (iv.) that the operator works in an upright position.

The machine consists of a frame which carries a revolving table that has two faces parallel to each other. Beneath this table there is another also parallel, which slides in and out horizontally, the amount of movement being determined by stops. The revolving table is also provided with stops, so that it is always brought into an exact horizontal position after it has been turned. The arrangement of the tables is clearly shown in the engraving. It will be noticed that the revolving table can be raised or lowered by means of the rack and pinion gear controlled by the capstan handle. Large weights are used to counterbalance the moving weight. It is necessary for the mould boxes to occupy a determined position on the table, and so they have small lugs cast on them, pierced with holes which correspond to the projecting pegs on the tables.

When making a mould one of the revolving table faces is brought into a horizontal position at the top. There are several small holes in the face of the table, provided so that the pattern can be secured to the face of the table by means of a screw. The part of the pattern, the mould of which is to be impressed in the lower half of the casting-box, is secured in this manner, and the lower half of the box then placed in position on the pegs. The levers shown in the centre of the lower table actuate clamps which hold the box firmly. The box having been clamped, sand is rammed in carefully, the back being strickled off and vented if necessary. The table is then turned round, lowered on to the pegs on the lowest table, the clamp released, and the box left free. The screw holding the pattern is taken out, and the table raised. The bottom table is then drawn forward, and the top half of the box placed on the lower half, and the remainder of the pattern put in position. Parting sand is sprinkled on the top of the lower mould, after which ordinary sand is rammed in. The table is then pushed back against the stop. The revolving table is lowered until the pins have engaged with the lugs of the top box. The box is then clamped to the table as before, and the table raised and turned round. Without being again turned, it is now lowered until the face of the lower side of the table touches the bottom box. The pattern in the box is then secured as before, that is by means of a screw, and withdrawn by raising the table. The other part of the pattern is then withdrawn from the top half of the box. The table is again turned round and lowered, and brought in its position relatively with the lower box, and the two are secured by bolts and nuts. The clamps are then released from the top half of the box, the table drawn forward, and the boxes lifted off the pegs ready for casting. If there are any cores they are now placed in position.

No special sand is required for moulding, and it will be seen from the description that the machine is capable of dealing with a large number of patterns that can be made in halves, or in such a manner that there are two flat faces. We have seen this machine at work, and were satisfied that the makers justified their claims. The work done by it was good, and required practically no finishing. The castings that we saw obtained from these moulds were quite clean, free



from blow-holes, and in only a very few cases could the junction of the two boxes be seen.

Three sizes of machines are made. No. 0 size takes boxes 9in. by 9in., and 12in. by 12in. by 4½in. deep. No. 2 takes boxes 12in. and 15in. square by 6in. deep, and the largest size takes boxes 15in. and 18in. square by 7½in. deep. The size of castings made is only limited by the size of the box.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

LOCOMOTIVE ECONOMY.

SIR, The leader in your issue of December 14th, on the "Coal Consumption of Large British Locomotives," and the reply thereto of the Locomotive Engineer of the Great Western Railway, raise an interesting point to all persons interested in the development and working of railways. Incidently there is raised the whole question of the absurdity of our railway system, or more properly, railway ring, and the present wasteful and extravagant practice in force on all our main lines, with regard to economy of working in locomotive engines. The matter was introduced under a political aspect, with which feature I am not at all concerned. Your statement that on engines of the "Atlantic" class the consumption on the heaviest and fastest trains is 60 lb. of coal per train mile would be supported by any person familiar with railway working.

Reference to the recorded coal consumption of our principal railways during recent years shows (the Great Western included) an average of over 50 lb. per train mile, making deduction for light running, and addition for the fact that only the heaviest and fastest trains are in question, the consumption cannot be less than that stated.

The Great Western is, of course, the best road in this country for fast and economical running, and the coal is Welsh. While I do not dispute the figures given, these no doubt refer to engine mileage, which was not in question at all; it is clearly evident that the train mileage consumption for all roads must exceed 60 per mile for engines of the latest type only. The loads on the Great Western Railway would also be less than those of the Scotch routes, and the figures given include, no doubt, also a number of trains of six or eight coaches only.

The loads on the North routes average the equivalent of 17 to 19 six-wheelers, and if the consumption of an express engine on such a train timed through at fifty-five miles per hour were accurately recorded and allowance made for lighting up the figures would positively not bear recording.

If any unsophisticated person doubts this statement he has only to ride as a passenger on these trains and note the working of the ash injector, where, by the medium of a 1½in. steam pipe, the train, passengers, and contiguous property are drenched with a stream of ashes.

Reference has been made on many occasions in your pages to the waste and extravagance of these large engines, and in at least one of your leaders, if not more, occurs the statement that the big engines were being overdone—that what was really wanted was not mere bigness, but improvements in boilers, valves, and the like, whereby economy might be assured; in other words, that there might be a little more skill and science imported into the design of our locomotives on British lines. The average horse-power of one of these engines even on the heaviest trains cannot exceed 800 and 55 × 60 = 3300, or a little over 4 lb. per indicated horse-power per hour, hardly a creditable figure in these days, and amply accounts for the absence of scientific tests with regard to the power and performances of locomotives on British lines.

The reply before mentioned is also remarkable because it is made the means of traducing the compound locomotive, bearing in mind the juggling that can be done with locomotive tests, how light running mileage and light train mileage can be used simply to prove anything, the mere citation of mileage consumption will not do at all; the test must be carried out in a scientific manner by independent persons to have the slightest value. When we find the compound locomotive doing the best work in France, and, indeed, in universal use there, working at speeds that our English engines cannot apparently accomplish, we cannot assume that this complete adoption by French engineers is just mere foolishness; we must consider the superiority latterly exhibited by French engineers in other branches of engineering, and a consideration of the engines designed and turned out by the great De Glehn firm, forces even the most insular and bigoted to confess to our everlasting national disgrace, that here, if anywhere, the problem of locomotive design is thoroughly comprehended. As the French have taken up and perfected compounding, so the Germans have perfected superheating, while our English engineers have been diligently employed in proving that improvement in locomotive engines is utterly impossible.

At the outset I referred to the railway ring, comprising directors and shareholders, as well as officials; so long as the shareholder gets his 4 to 6 per cent. he is not interested in improvement, and there is thus no incentive to economy. Any surplus which might happen to be provided above these rates in equity would go to the trader in reduced rates; to the employé in increased wages; the shareholder cannot hope to benefit further, one at least of our main lines would and could pay 15 per cent. were this not so. As a result, railway inefficiency dogs us at every step and clogs our whole national existence; meanwhile the supremacy in matters engineering drifts more and more into the foreigners' hands. The all-powerful railway rings ramifies every stratum of business, to protest against it is useless. In only another country, namely, China, would such a state of things be tolerated. This year we have had two serious railway accidents; in the Salisbury accident the prolonged controversy which went on in your columns proves that the reasons advanced for the accident were far from satisfactory. There is an uneasy feeling that if all details were known a different complexion would be thrown on the state of affairs. With regard to the Grantham accident, it is openly admitted that no tangible cause can be found. This is thoroughly Chinese and English. I prefer to subscribe myself simply as

December 24th. PROGRESS.

THE STEAM OMNIBUS.

SIR,—In your issue of last week my remarks on Mr. Clarkson's paper on his steam omnibus is wrongly reported at one point. In your report I am made to say that "when his boiler starts priming the only remedy is to shut off steam." What I said, or what I meant to say, was "that when his boiler started priming, the only remedy was to shut off the feed-water by hand until the steam again reached its normal working temperature; but this did not constitute automatic control."

In a boiler such as Mr. Clarkson's the coils may be divided into three sections, which, though all in series, have the separate functions of "feed-heater," "evaporator," and "superheater," and priming of course means that the superheater has become filled with wet steam or water.

Now, as the pump is sending in more water than the burner can raise into steam of the right temperature, and the engine takes all it can get of the steam in this condition, there is no chance of the burner overtaking its work and bringing things normal; then if steam is shut off, and the engine stopped, the pressure rapidly rises, and the pressure control shuts down the burner, but it is the pressure of hot water, not the pressure of superheated steam, so that when he starts again the same priming conditions prevail; therefore, the only remedy is what I have mentioned. Regarding your leading article on the subject, I do not consider the difficulties to be so great as you seem to think, and I do not believe that finality in the thermal control of flash generators has been reached by Mr. Clarkson or anyone else, any more than that James Watt reached finality in steam engine governing. My own views on the matter have been given in a written communication I have sent in to supplement the few remarks I was able to make at the meeting in the time given me.

Mentioning the burner question I would like to state that the margin of efficient working temperature is not nearly so fine as Professor Hele-Shaw seems to think it is.

I have proved both by experiment and experience that oil under pressure, such as it is in these burners, will not dissociate under a wide range of temperature so long as the pressure is well maintained. A greater source of trouble with them than dissociation is condensation of the vapour after it has been properly vapourised. This condensation takes place between the coil and the nipple, and in the inducing tube, and is in proportion to the dimensions of these parts.

December 22nd. J. JOHNSTON.

SIR,—I have read with great interest your leading article on the "Steam Omnibus." I am much surprised, however, to learn that Dr. Hele-Shaw, during a trip on a Chelmsford steam omnibus, saw the pressure gauge rise to 1000 lb., and "wished himself anywhere else." I am also much astonished that such experienced persons as yourselves express complete agreement with the learned gentleman's views, or rather I should say his fears.

Really, when such high authorities labour under such an entire and complete misconception of the true nature of a "flash" steam generator, I am not surprised that a certain section of the general public have a prejudice against steam cars. They have been misled by the parrot cry, which I thought was now quite dead: "Steam cars—nasty, dangerous things; don't you have anything to do with them; the boiler will burst, and then where are you?" This cry was greatly used by the advocates of petrol—*i.e.*, internal-combustion engined cars—against steam in the early days of motor cars, and to it must be attributed a great many of the false ideas now held by the public about steam motor vehicles. I had really thought THE ENGINEER was above such ignorance.

Surely, every one who has driven—I had almost said every one who has ever sat on, but Dr. Hele-Shaw is evidently not among the number—a steam car with a "flash" generator, knows that in the worst case, if the boiler does, to use the untechnical language of the "man in the street," "bust," nothing happens. A "flash" boiler, which is made up of coils of steel tubing, cannot "bust." The utmost that can happen is the rupture of one or more of the tubes. What is the result? A slight escape, a mere puff, in fact, of steam, and the car stops, and you have the very annoying job of taking down your generator and replacing the burst tube. These "flash" generators too, are tested far above 1000 per square inch, and so long as they are not overheated they will never give out. It is the overheating, not the excessive pressure, which causes the tubes first to bulge or balloon—almost exactly like a weak place in an india-rubber tube, such as the inner tube of a tyre—and then to crack.

I have myself frequently been on "flash" boilered steam cars when a tube has "burst." The last time this happened we found that—owing to there being no thermostatic arrangement on the car—the whole boiler was red hot from top to bottom, the lower tubes being practically at a white heat. The pressure in the boiler was at the time the tube went about 800 lb.—900 lb. per square inch. The bogey of "danger from the boiler bursting" on a flash-boilered steam car has been worked long enough; I think it might be "given a rest."

The reason for the great damage caused by the explosion of a wet steam boiler, *i.e.*, one of the ordinary types, is the presence under pressure of a large quantity of water in the same vessel as that which contains the steam. When the explosion, by letting out the steam, removes the pressure this water instantly turns into steam and makes the effects of the explosion much worse

This large body of water does [not exist in the "flash" boiler. The small quantity there is can do no harm when it escapes in the form of steam through the crack in the tube.

December 23rd. E. W. SHEPPEE.

A CENTRIFUGAL PROBLEM.

SIR,—Accepting Professor Fitzgerald's dictum that centrifugal force is not set up by the cyclist within the sphere, "A. B. C." claims, in your issue of the 21st, that a "pill" on a disc is compelled, under the conditions he assumes, to increase its distance from the centre of that disc. He says:—"Whereas the rotation of the sphere is causing it to move forwards in a straight line, the ground on which it moves is speeding under it circumferentially, *and this latter circumstance is responsible for the movement of the sphere radially outwards from the centre of the disc.*" The premiss, which I have italicised, seems to me inaccurate. There can be no component radial to the disc in the thrust between sphere and disc, for presumably they make contact at a point, and, the disc radius passing through that point, is normal to the plane of rotation of the sphere.

Even were the sphere soft, so that an area of contact instead of a point of contact existed between sphere and disc, then the outward thrust by the disc on one half of the contact area at one side of a disc radius would be equilibrated by an inward thrust on the other half at the opposite side.

The so-called proof also seems to fail. A certain hypothesis is set up, after which a disturbing force is introduced to bring about displacement of the sphere. In the new position (H) into which the sphere is displaced it may certainly be made to set up a thrust in the direction of the edge of the disc. But this can be done only by starting a new hypothesis involving new conditions.

Under no circumstances can "A.B C." produce the radial force that his suggested feat demands, so long as he keeps within the four corners of his original suggestion and refrains from introducing external additional forces. Why not experiment with a small disc against the inside of a wheel rim, if any doubt exists?

London. WM. JNO. TENNANT.

SIR,—The problem put forward by "A. B. C." is one that cannot fail to be of interest to anyone who happens to dwell on a revolving spheroid. I am surprised he still retains his opinion after what has already appeared in your columns, but possibly the letters of December 21st will have some effect. It is a perfectly well-established fact that a body can only experience centrifugal force when it is moving relatively to the centre of repulsion.

"A. B. C." is wrong again about the case he describes this week. The ball would not travel outwards. He commences his proof by saying that it would move along a straight line if the disc were at rest. This is true; but the revolution of the disc completely kills this tendency. He speaks afterwards of the ball—do not let us call it a sphere, as this word is applied to the large member of the other problem—as a rectilinearly moving body. This is the root of the fallacy, being an incorrect description. It is simply a rotating body, and nothing more, in itself. If it were dropped on the ground, it would advance by virtue of the friction between its periphery and the ground, but the effect of this friction is entirely eliminated by the backward movement of the disc, and the result produced is the same as if the ball and disc were perfectly smooth, and the ball slipped round without changing its position. For the ball to arrive at H it would have to be originally supplied with a horizontal velocity = e, not rotational. If "A. B. C." denies this, how would he distinguish between the two cases?

December 24th. C. F. DENDY MARSHALL.

SIR,—"A. B. C.'s" so-called proof is a very doubtful one; when two or more forces are acting together they may be resolved into their component parts; but in "A. B. C.'s" proof he introduces a consideration, namely, the removal of the sphere farther from the centre, which is the very point to be proved, and "A B. C." has no right to assume that this takes place. No doubt there is a tendency in the sphere to move in the direction of F, but this tendency is entirely destroyed by the movement of the disc. "A. B. C." says, "for whereas the rotation of the sphere is causing it to move forwards in a straight line," this is not so, it does not so move forward, as "A. B. C." himself admits when he says in an earlier part of his letter, that it is prevented from rolling forwards "by the equal and opposite velocity of the disc at the point of contact." If the sphere could actually move towards F, and so acquire a greater circumferential velocity, "A. B. C." would be enabled to prove his point, but "A. B. C." does not maintain that the sphere really moves nearer to F.

Why should this mysterious force, which "A. B. C." admits is not centrifugal force, act on the wheels of the cycle and not also on the cyclist, in the hollow revolving sphere?

If the cyclist were riding outside the top of the sphere, instead of inside, does "A. B. C." think that this mysterious force would remove the cycle farther from the centre? C. T. P.

December 25th.

LOFTUS PERKINS.

SIR,—From time to time I have noticed reference to the late Mr. Loftus Perkins in your paper, and especially just lately during the discussion on Mr. Clarkson's paper. As I was Mr. Perkins' personal assistant for some years—1871 to 1875, *i.e.*, during his busiest period—I had a good deal to do with the Fulga (tug) trials, the Emily (launch), the Brussels tram engines, the several traction engines, and the scores of other schemes Mr. Perkins had, and it struck me that some of your readers might like to know more of this clever and true-hearted gentleman and of his engines, boilers, &c. If so, I shall be pleased to answer to the best of my ability any letter addressed through you.

December 20th. W. G. C.

THE GRANTHAM ACCIDENT.

SIR,—I have just been reading the first part of your leading article in THE ENGINEER of December 21st, 1906, and I feel that it is only my duty to say a word or two on behalf of the engine-men You said, "There will be general agreement with Colonel von Donop's remark that it ought to be a rigid rule that a driver who leaves his work through any form of sickness should pass the doctor before he returns to his responsible duties." This I agree with and I may tell you this is now carried out on some of our railways, both with drivers and firemen.

Now, in the interest of safety, I should like to insert another clause:

That no man but an experienced fireman shall act as fireman on express trains. I will give my reasons for inserting this clause. First, no man is infallible. Secondly, that it is only practical experience that teaches the young fireman to realise the responsibility that rests with him and the driver. Thirdly, that it takes a young fireman a long time to get a good knowledge of the road, and to retain it so as to know his exact position on the road after he has been putting some coals on the fire at night.

It may be interesting to you, Mr. Editor, to know that there is a great deal of difference between knowing the road in the daylight and knowing the road in the dark. The experienced fireman knows the road, he can picture the road "as well as the driver," from start to finish, he has had perhaps years' experience. I myself have had nine years and one month's experience as fireman, and fifteen years' experience of railway work. My experience teaches me that the knowledge of the road is very important in the interest of safety. A LOCOMOTIVE FIREMAN.

London, E., December 25th.

LIGHTING OF RAILWAY PREMISES: INDOOR AND OUTDOOR.*

By Mr. HENRY FOWLER, Member, of Derby.

ALTHOUGH from the title the above subject may only appear to appeal to a small class of members, yet it will, on consideration, be seen that on a railway, with its various buildings, stations, yards, shops, &c., nearly all conditions occur which are likely to be met with by engineers. The examples given in this paper are naturally taken from the line on which the author is employed—the Midland—and has charge of lighting by gas and oil.

The lighting on a railway is chiefly provided by means of oil, gas, or electricity, the choice of the agent used depending upon its availability and other circumstances. It may be generally assumed, however, that oil in ordinary lamps is only used at unimportant points, and where no other means are available. Gas is probably the most general illuminant, and has been able to maintain its position in the majority of places, owing to the introduction of incandescent mantles by Auer von Welsbach. Recently several systems have been introduced of compressing the gas to allow of a better mixture of gas and air being obtained, and a larger unit of light being where necessary available.

Electricity was first chiefly used in arc lamps, and has proved very satisfactory where a large area has had to be illuminated. But recently, on railways as elsewhere, the need of a cheaper and smaller light has been felt, and this will doubtless be shortly supplied by some of the various types of lamps—Nernst, mercury vapour, &c.—at present being perfected.

The illumination of an object not only depends upon the power of the light itself, but on the reflector, the colour and character of the surrounding substances, and the position of the object to be illuminated in relation to the light itself. Under most ordinary circumstances the objects to be illuminated lie either on a horizontal or a vertical plane. On a railway proper, the station platforms are of the former type, and the station walls and wagon sides and ends of the latter.

It is now generally accepted that illumination should be expressed in terms of candles, or portions of a candle, at the distance of a foot, and to the unit of 1 candle at 1ft. has been given the name of a foot-candle. This being the case, the theoretical illumination of any point from a single unaided light can be readily obtained. By simple formulæ the illumination at a

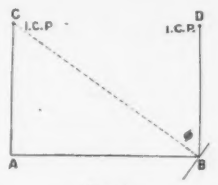


Fig. 1

point in any plane may be readily determined, always assuming that the intensity X is known for the definite direction C B, Fig. 1. In actual practice it is found that with nearly all lights, whether electric or gas, the intensity varies considerably with the angle A C B, and therefore each point must be considered separately. The author has, however, for several years worked with a photometer which measures the total illumination on a horizontal plane with actual examples of lighting, and it is with the results of this work that he proposes to deal. The instrument is a development of the one devised by Messrs. Preece and Trotter and improved by Mr. A. P. Trotter. The apparatus is shown in Fig. 2. The author is perfectly well aware that objection may be raised on

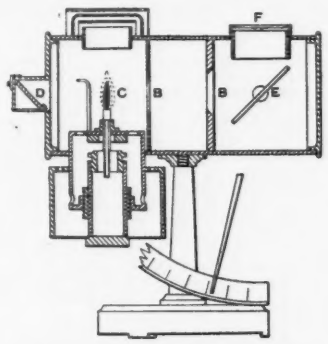


Fig. 2—PORTABLE PHOTOMETER

the ground that this instrument is not an absolutely correct one, but it is the only one of its kind on the market, and he has found that in the same hands it gives comparable results.

Another and perhaps a more reliable type of portable photometer is that of Messrs. Simmance and Abady, in which their flicker photometer is used to obtain an absolutely definite reading.

Horizontal and vertical illumination.—The question of whether in estimating the lighting required the horizontal or the vertical illumination is to be considered is dependent upon circumstances, and upon the decision arrived at depends the height at which the lamps should be fixed. As a general rule, however, the author has found that where the horizontal illumination is properly provided for, the vertical will be found to be satisfactory, and in all the curves which follow the former is the illumination which has been measured.

PASSENGER STATION LIGHTING.

Arrangements of lights.—The space to be lighted in a station consists mainly of the platforms, and this necessitates the lights being placed in long lines down these platforms. The best position for these is nearly in the centre of the space to be lighted. Where there is a wall or building on one side, and the platform edge on the other, they should be slightly nearer the former, as the lamps are usually employed, in addition to their use for lighting purposes, as a means of denoting the name of the station. On open platforms, columns, &c., form obstructions, and are therefore placed so as to leave as great a space as necessary between them and the platform edge. It is absolutely essential that the edge of the platform itself should be well defined.

Height.—This is a most important point, not only in station lighting, but in all other, as upon it depends the general character of the horizontal illumination. The ideal arrangement is to have a light of great intensity fixed at great height, when the illumination will be as even as possible. This, of course, is impracticable and would lead to much loss of light, as only a small portion of the spherical intensity would be utilised. In actual practice the distance the lights are apart has to be taken into account, in ordinary railway work the ratio for station lighting is usually not less than 1 to 5 or 1 to 6, and the effect is good. An electric arc should, if patchiness is to be avoided, be placed fairly high. Above all things, in lighting any space effectively, the fault of patchiness should be avoided. All variations of illumination should be as gradual as possible, and this is one of the chief reasons for surrounding arc lamps with opaque globes, which, although they retard a portion of the light, allow a better general effect by distributing the light more evenly. On a railway station the lowness of the roof often prevents the lights being placed at the desired height, and in these cases the only satisfactory method is to use a number of small units close together so that contrasts in illumination may not be too marked.

OIL LIGHTING.

Its inefficiency.—It is scarcely necessary to say that lighting by oil is only employed at small stations where no other form of illumination is available. It requires more attention than any other type, but at a small station this is not usually a matter of importance. In some exposed situations it is a matter of impossibility to light the lamps in position during very rough weather, and in such instances special inner lamp cases have to be provided, by which means the lamps can be lighted indoors and the whole carried to and placed in the ordinary lamp case. The advantages of oil lighting are its simplicity and the low cost per burner-hour for a light which, in many cases, is sufficient for the use to which it is put.

Flat-flame burners.—There are several types of oil lamps used for station lighting, and the simplest of these is of the ordinary type, using a flat-flame wick with a "Rippingille" or other type of burner. These give about eight candles for a consumption of 0·0082 gallon of oil per hour, whilst with the cisterns used on the Midland Railway they will burn about six hours without attention.

Defries pneumatic burners.—These lamps have a 0·95in. circular wick, and a cistern which hangs over the burner containing sufficient oil for forty-eight hours' burning. They are fairly satisfactory, but require to be kept clean or they are liable to leak. They give a light of 10·3 candles for the expenditure of 0·0116 gallon of oil per hour.

Veritas burners.—These are lamps with centre draught and circular burners of various diameters. The 80-candle type has a wick with a diameter of 1·8in., and a vessel which contains oil for five hours' burning. The light given is 74·19 candles for a consumption of 0·0459 gallon of oil per hour. These are the most efficient and satisfactory oil lamps of the ordinary type, but they are somewhat sensitive to wind, and the lamp-cases used with them require to be specially constructed to prevent draughts.

A summary of the efficiency, &c., of these three types of burners is given in Table I.:—

TABLE I.

Type of burner.	Size of wick.	Candle-power.	Consumption of oil per hour.	Consumption of oil per candle per hour.	Candle-hours for 1 gallon of oil.
	In.		Gallon.	Grains.	
Flat-flame—Rippingille	0·9 wide	7·98	0·0082	57	970·17
Defries — pneumatic	0·95 diam.	10·3	0·0116	62·2	889·06
Veritas	1·8 diam.	74·19	0·0459	50·13	1103·11

Many attempts have been made to use ordinary petroleum directly with incandescent mantles, but only with partial success, as special care is needed to keep the flame purely a Bunsen one There is, however, a highly successful lamp which vaporises the petroleum and uses the gas formed with an incandescent mantle. This is the Kitson light, which has been used in this country now for about five years, and a drawing of which is given in Fig. 3.

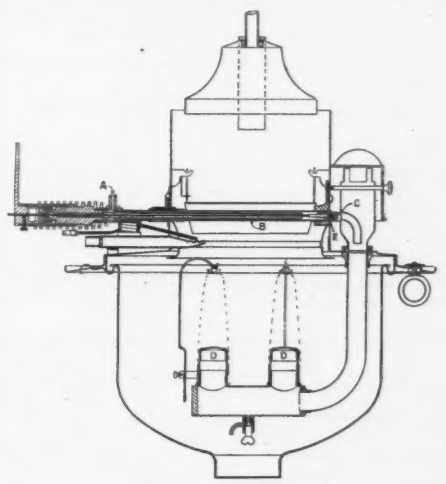


Fig 3—THE KITSON LAMP

The average candle-power of one of these lamps tested on a photometer bar was 781 candles for a consumption of oil of 0·1135 gal. per hour. This works out at 8·3 grains per candle-hour, which, of course, is far in advance of any other type of lighting by means of oil. The cost of maintenance varies very much with their situation. From the candle-power of these lamps it will be seen that they are only suitable for station-lighting when they can be placed high up above the platform, unless a very strong light is required.

Other lighting for small stations: Acetylene.—Of the various other systems of lighting small stations, one of the most satisfactory is the use of acetylene, but its expense has prevented its being generally adopted. To give a light comparable with that of a Veritas oil-lamp, at least 1ft. per hour must be burnt, and with carbide at £15 per ton this means a cost of 0·36d. per cubic foot; and assuming that this gave 50 candle-power, the same light could be given with a Veritas oil-lamp for the same cost, even if oil were 8d. per gallon, neglecting cost of generation. (It has been assumed that 1 candle-hour takes 50 grains.) Acetylene can therefore only be used under special conditions.

Carburetted air.—Since the cheapening of the cost of petrol, very many attempts have been made to use it for carburetting air for use with incandescent burners, the gas thus made to be used through ordinary gas-pipes to supply these burners.

Petrol lamps.—Many types of independent petrol lamps are on the market, and these in the majority of cases have a vaporiser under the burner, which is provided with an incandescent mantle, the petrol being fed from a supply above the lamp. A portion of the heat from the burner is thrown down on to the vaporiser, but as petrol is so volatile, not much is required for this purpose. As a rule these lamps require their vaporisers to be heated slightly before turning the petrol on. Their disadvantages are the attention they require to light and keep in order, and the danger in having so many small supplies of petrol on the premises. In a lamp recently put on the market, the petrol is allowed to soak into an absorbent block, and gas is made by syphoning air through this to the burner. Other lamps on somewhat similar principles

* The Institution of Mechanical Engineers.

to the first-mentioned of this type use methylated spirit, but this adds materially to the cost.

The following are the results of some of the lamps of this type with which the author has experimented, and which use petrol :—

TABLE II.

Lamp.	Candle-power.	Consumption of petrol per hour.	Candle-hours per gallon of petrol.	Candle-power after one hour's burning.
		Grains.		
A	41·94 (average)	555	3703·7	—
B	35·92 ,,	700	2515·4	—
C	38·0 ,,	840	2217·2	—
D	45·92 (1st hour)	908·66	2291·8	42·5

The author believes that there is a future before petrol-fed lamps, but the time for their general adoption has not yet come.

Gas lighting: flat-flame.—Until a little more than ten years ago, except in a very few isolated cases, gas was the general illuminant for stations of any importance, and was almost universally used in an open or flat-flame burner. Although this type of burner is rapidly becoming out of date on all stations where many trains are run at night, yet it still supplies the greater part of the lighting on several of our British lines. On every company's system there is a number of stations on branches, &c., where the trains are not run late in the evening, and where artificial light is only required for a short period each evening during a few of the winter months. The burners most usually employed are No. 4 and No 5, which, with 18-candle gas for a consumption of 4·9 and 5·3 cubic feet per hour, give on the photometer bar a light of 9·7 and 12·1 candles respectively. When employed on small stations one of these burners is usually placed in each of the lamps, which are fixed from 50ft. to 60ft. apart, the burners being 9ft. 6in. above platform level.

Regenerative gas lamps.—Some years ago F. Siemens introduced his regenerative gas lamp, which, although requiring more attention, was a great advance on the flat-flame lamp in efficiency. It is not necessary to go into details of the construction, but it may simply be said that the principle is that of the waste hot gases heating the air necessary for the combustion of the illuminating gas. The burners give a flame of the inverted mushroom type, which is enclosed in a semi-spherical glass globe. This type of burner is still used on some stations, particularly as suspended lamps. One tested by the author gave 58·91 candles for a consumption of 7·65 cubic feet of gas per hour, which shows a very great advance in efficiency over the ordinary flat-flame burner.

Incandescent gas lamps.—The greatest stride in gas lighting on railways and elsewhere was undoubtedly made when Auer von Welsbach devised his system of utilising a Bunsen gas-flame for heating to incandescence a mantle containing the rare earths Thorium and Cerium. The construction, too, of the ordinary incandescent burner is too well known to need description. An ordinary C burner, using a gas giving 700 B.T.U. per cubic foot, and consuming 3·0 cubic feet per hour, can be depended upon for giving a light on a photometer bar averaging 44·25 candles for 1000 hours. On the Midland Railway there were in use on 28th June, 1906, 48,392 of these burners, and, although they are employed in all situations, the mantle consumption cannot be said to be high, as it only averaged 5·2 mantles per burner per annum. Under ordinary circumstances with pillar lamps, where a good foundation for the pillar has been secured, and in nearly all cases with suspended lamps, it has not been found necessary to provide any type of anti-vibrating apparatus to preserve the mantles. When, however, a good foundation cannot be secured, and the vibration is excessive, the use of a simple apparatus, consisting of a frame suspended by a spring on which the burner is fixed, and to which gas is supplied by a rubber connection at the bottom, has been found advantageous.

Cost of maintaining one incandescent burner for one year to June, 1906 :—

Mantles	5·20d. per annum.
Chimneys	1·27d. ,,
Forks	0·33d. ,,
Wages	1s. 4·16d. ,,

The author is perfectly aware that the various Kern type of burners with their longer and better designed mixing chambers for the gas and air give a higher efficiency, but he has found that they require greater attention than those of the C type. On the photometer bar this type of burner—Kern—will give over twenty candles per cubic foot of gas burnt per hour, but for the reason stated he has not recommended their general use on the line.

As examples of the advantage of the adoption of incandescent gas burners in place of flat-flame burners, the following cases may be taken :—

TABLE III.

	A.		B.	
Flat-flame burners dispensed with ..	130		134	
Total candle-power of these	1300		1340	
Incandescent burners fixed	98		85	
Total candle-power of these	4336		3761	
Gas used per annum when flat flame burners were employed..	1,635,200 cu. ft.		2,015,700 cu. ft.	
Gas used per annum when incandescent burners were substituted ..	921,000 cu. ft.		1,388,200 cu. ft.	
Percentage increase in candle-power ..	233 %		181 %	
Percentage decrease in gas consumption	43·68 %		31·13 %	
	Total	Per burner.	Total.	Per burner.
Maintenance of incandescent burners per annum—				
Mantles	4'4	4·22	750	8·82
Chimneys	90	0·92	104	1·22
Forks	20	0·204	16	0·19
Wages	£6 7s. 6d	1/3·61d.	£4 5s. 8d	1/0·1d.

The cost of making the alteration was £41 10s. in case A and £36 10s. in case B, and it will be seen that this will soon be wiped off by the saving shown, even after making allowance for the cost of maintaining the incandescent burners.

High-pressure incandescent gas.—Many attempts have been made to get a greater efficiency out of a cubic foot of gas than is given by an ordinary incandescent burner at pressures up to 2in. of water. Some four or five years ago it was found that by using a much higher pressure than usual and allowing the air and gas to mix together in a longer chamber, better results were obtained. The pressure used was that of from 8in. to 10in. of water, and the burners somewhat of the Sugg type. The mantles are without chimney, and at a pressure of 10in. of water give 240·68 candles with a consumption of 10·18 cubic feet of gas per hour. It would seem that the best efficiency is obtained with a burner of this size, and it is not always that so large an unit of light is required, but, when it is, the use of such burners is economical.

More recently several systems of lighting have been devised in which the pressure at which the gas is burnt is very much higher, rising in some cases to 5·4in. of water. The result is that a still greater efficiency per cubic foot is obtained, but the unit of light is raised higher than is usually required for railway purposes.

Interior lighting.—Interior lighting on a station in the majority of places is confined to small rooms, with the result that the light is usually required at some particular point, and consequently it is placed as near this point as possible. About the largest interior spaces requiring attention are parcel offices, and in these it is found that an illumination varying from 0·9 of a foot-candle on the floor gives good results. This can be obtained by three-light suspended C gas burners placed under an enamelled reflector.

TABLE IV.

Burner.	Pressure.	Consumption of gas per hour.	Candle-power.	Candle-power per cubic feet per hour.
	Inches.	Cubic feet.		
A	1·8	2·805	77·51	27·63
B	1·0	1·43	25·37	17·74
C	1·0	2·29	50·54	20·06
D	1·5	1·525	24·964	16·37
E	3·0	2·99	84·31	28·2
F	3·0	1·015	27·54	27·13

ELECTRIC LIGHTING.

Electric lighting is at present, owing to the development of Nernst, mercury vapour lamps, &c., somewhat in a state of transition.

Arc lighting.—In order that this type of lighting may be used to the greatest advantage on a station, it is necessary, owing to the high unit of light given by the most satisfactory type of lamp, that it should be placed fairly high up, and, in fact, that the ratio of height of lamp to distance apart should not be greater than 1 to 4 or 5. One disadvantage of a very high light is the difficulty of attending to it in re-carboning unless arrangements are made

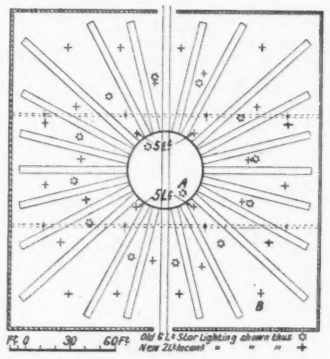


Fig. 4—PLAN OF ENGINE SHED

for dropping the lamp. The type of lamp usually employed is a 10-ampère, 500-watt one, and unless otherwise stated this is the class of lamp used in all the curves which follow. In some cases enclosed types of arcs, using, however, about the same amount of current, are employed. This type of lighting is particularly good when the space to be lighted is large, and when the height required for satisfactory illumination can be obtained.

Incandescent electric lighting.—With some railway companies these lights are employed for lighting platforms on some of the smaller stations, but as a reliable lamp takes at least 3·5 watts per candle, current must be cheap in order to make it at all economical.

GOODS YARDS AND SIDINGS.

In the previous section detailed description was given, where required, of each particular lamp as mentioned, and it is not, therefore, necessary to revert to them, but simply to mention them when referring to the effects obtained by their use.

In lighting these places, as distinct from goods sheds, two conditions may obtain ; it may be that it is necessary to provide for lighting a space, as, for instance, the entrance of a yard, or a particular point, such as a capstan. Upon these considerations the type of light used will depend. For the lighting of the yards three-light incandescent gas lamps, about 80ft. to 100ft. apart, or arc lamps about 100ft. to 120ft. apart, give a good effect, and quite sufficient illumination under ordinary conditions. It frequently happens, however, that the necessity for providing light at some particular point, such as a crane, capstan, crossing, &c., causes the lamps to be placed much closer together. In small yards, where neither electricity nor gas is available, Veritas oil lamps in suitable cases

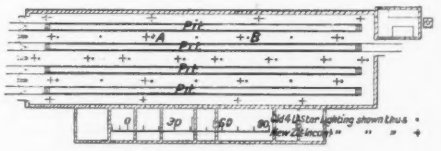


Fig. 5—PLAN OF ENGINE SHED

may be used. In the lighting of sidings the chief position to be considered is that of the points. Here it is necessary not only to light the points themselves and the position of the "dummy" for changing them, where provided, but also to show when a wagon is standing clear where the roads diverge, so that shunting may take place safely by it. In some cases special lighting has to be provided, and, as a case in point, the author would quote gravitation sidings, such as now exist on most railways. At points where trains are broken up on these sidings a particularly good light is required, and a minimum illumination of 0·15 foot-candle found none too much.

Locomotive sheds.—The sheds of the Midland Railway Company are of two types, either square—"round"—with a turntable in the centre, and pits radiating from it, or rectangular with an entrance at one end, and pits running down the length of the shed. Examples of these are shown on Figs. 4 and 5. The lighting was formerly carried out by means of star or similar gas lights with four, six, or eight burners, each consuming about 5 cubic feet per hour. In the case of the "round" sheds these lights were placed between every other pit, with the result that one side of each engine was left in darkness. Upon the advent of the incandescent burner these old lights were replaced by two-light incandescent burners, either in lamps or under shades, which were placed between each pit. The result was that not only was a better and more evenly distributed light obtained, but a considerable economy was effected in the cost of lighting.

Lighting of workshops.—With the exception of the shops in which the locomotives or carriages themselves are erected or repaired, the general conditions and arrangements in railway works are very similar to those found in any engineering works.

Lighting of locomotive erecting shops.—In lighting a locomotive erecting shop, certain initial difficulties are met with. These are the need of a good general well-diffused light, and the fact that, as cranes run down the whole width and length of the shops, the light must be at least 29ft. above the floor level. The author was met with these difficulties when asked to improve the illumination of a large erecting shop of three bays, each measuring 450ft. by 50ft. At first arc lamps, under large whitewashed reflecting boards, were tried above the cranes, but for one reason or another were not wholly satisfactory. These lamps were then superseded by arcs placed between the columns separating the bays, but this did not provide a sufficient light in the centre of the shop. About this time a smaller shop was erected at Kentish Town, and the author lighted this by high-pressure gas burners, placing three of these under a whitewashed reflector. The results are very satisfactory, a steady well-diffused light being obtained, whilst the burners have required little attention and the consumption of mantles has been low. In this case, as so small a number of burners are used, water is employed for raising the gas pressure from 1in. of water to 8in. of water, and as an old-type compressor was fixed, the water consumption has been somewhat high, being 327 gallons per 1000 cubic feet of gas compressed. The success of this lighting led to the same system being adopted at the large shop previously mentioned.

Fitting shops.—In fitting and machine shops, although a general light is required, yet particular points require special attention unless the general illumination is very good. In the discussion on Sir B. A. Dobson's paper, Mr. J. A. F. Aspinall showed by photographs, &c., the success achieved by fixing arc lamps under large whitewashed screens in the fitting shop at Horwich. The construction of this building has allowed of the systematic arrangement of a large number of arc lamps, and the author, who has worked both on machines and at the bench in this shop, can testify to the excellent effect given.

In the shops he has had to deal with the construction has not admitted of the employment of large units of light, as, to use them successfully, they must be placed at a considerable height above the surface to be illuminated. With gas available at a very low cost, extensive use has been made of the two-light incandescent gas fitting under a 28in. enamelled shade as already described.

In some cases, owing to the provision of cranes, or from other causes, it has been found necessary to provide a special light for a vice. In such positions a single light with a special anti-vibrator has proved useful. These have also been employed to light a row of lathes fixed against a wall, and where it was not thought advisable to provide large units of light high up. In these circumstances they are fixed to the wall behind the lathe.

Paint shop.—In both locomotive and carriage paint shops, not only is a good light required, but it has to be provided in long rows to illuminate thoroughly the vehicles on each side. In dealing with these cases, a two-light incandescent fitting has been found very successful.

Carriage shop.—With lighting of carriage shops generally the same conditions occur as are found in locomotive paint shops.

Iron foundry.—The lighting of ironfoundries seems to be one particularly suited to arc lamps, but the author, from his experience with high-pressure gas lights in the brassfoundry referred to, believes that this system of gas lighting may successfully be employed in illuminating what is usually the one dark spot about a works. At Derby the side of the foundry on which light work is carried out, and along which no crane runs, has been lighted for some time with ordinary incandescent gas burners. On the section where a crane is necessary to deal with heavy castings, &c., high-pressure gas lights under whitewashed reflectors have been installed.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, December 12th.

THERE is an urgent demand for locomotives and cars, particularly for steel cars, notwithstanding the overcrowded condition of locomotive shops and car plants. The Pennsylvania Railroad has just placed an order for 250 steel cars, and the Bessemer and Lake Erie Road has just placed an order for a like number. Orders for steel cars for export have been placed for shipment to the Philippines, China, and for the Chilian State Railway. These orders call for the dispatch of some 10,000 tons of steel, and the negotiations for this quantity of steel were started to-day. The Lehigh Valley Railroad has placed orders for 50 engines with the American Locomotive Company, and the Missouri Pacific has placed an order for 100, of which 25 will be built at Philadelphia.

Billets are being imported from Liverpool, 300 tons having recently arrived. The Brooklyn Heights Railroad has just placed an order for 5000 tons of structural steel. Two furnaces of 350 tons daily capacity are to be erected at Rome, Ga. On account of the shortage of steel 500 employés out of 3000 were laid off last Saturday at the Pressed Steel Car Works, Pittsburg. Reports from various sections of the country indicate a growing shortage of material, and there is no remedy in sight.

The Brooklyn Rapid Transit Company will make extensive improvements along its line which will force it into the market for material. The New York Central Railroad is preparing to make extensive improvements between this city which will call for large quantities of structural steel. Orders for steel rails are dropping off, but for plates and shapes the greatest activity prevails.

The light rail business, however, is an exception as to steel rails, and all of the mills engaged in their manufacture are booking as much business as they care to, and have knowledge of a great deal of business which can be had. An order for 20,000 tons is the only large order for standard rails that has been placed for some time. Structural material is about to be advanced either 2 dols. or 4 dols. per ton, and it is intimated that standard rails may also be advanced, but this is not accepted as a probability, because of the well-known policy of the United States Steel Corporation to maintain prices at 28 dols. per ton, which has been the price for several years. Orders for several thousand tons of steel plates have just been placed by western car builders, and eastern mills which were called upon to furnish plates within thirty days obtained a premium of 2 dols. per ton. Foreign iron is also moving up steadily, the advance within a week being 3s. per ton. Scotch iron is held as high as 26 dols. delivered.

The copper market continues very strong, although buyers are not purchasing very freely. It is only copper for early delivery that can be sold at the high figures now prevailing. Arrangements are being made for an increased output of copper next year, and the supply will be considerably greater. A phenomenal advance was made in copper last week of 5·60 dols. for lake and 2·80 dols. for electrolitic and casting. The production of copper during the present year, based upon the amount put out during the first eleven months, will probably reach 1,000,000,000 tons. The most conservative estimates point to a production of 965,000,000 lb. for the year.

A SPEED limit for motor cars will come into force at Guildford on January 1st. The restriction applies to "so much of London-road as extends from its junction with High-street to a point in the road situate about 100 yards or thereabouts north of its junction with York-road and Waterloo-road ; High-street ; the Town Bridge ; Portsmouth-road from the Town Bridge to its junction with the turning known as Mount Pleasant ; North-street ; so much of Farnham-road as extends from a point in the said road situate twenty yards or thereabouts west of Denzil-road to its junction with Portsmouth-road ; Chertsey-street, extending from its junction with Martyr-road to its junction with High-street ; Quarry-street to the borough boundary ; and so much of the Epsom-road as extends for a distance of twenty yards or thereabouts in an easterly direction from its junction with the London-road."

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Trade in 1906.

OPENING with an advance in Staffordshire marked bars of 10s. per ton, which followed upon a similar advance in the previous November, there seemed every probability in January of a continuance of the trade revival which had marked the last four months of 1905. Unmarked bars, which during 1905 had gained £1 per ton, were in January advanced 5s. per ton, so also were iron hoops, and gas tube strip was advanced 10s. per ton. The January quarterly meeting was a record one, and a parallel could only be found in the conditions surrounding the boom period of 1899 and 1900. All sections of trade were strong, and expectations of a busy twelvemonth ran high. The £9 to which marked bars were raised was a figure which had not been previously touched in the Midlands for five years, and so buoyant was the common bar trade that many firms had made sales at £7 5s. per ton, to which price the standard was raised by the Unmarked Bar Iron Association prior to the advance being resolved upon. The new basis for tube strip became £7 10s. to £7 12s. 6d., and, in fact, the advance in this department was voted one of the most remarkable movements of the January meeting. Sheets for galvanising and merchant purposes, which had put on 20s. per ton during the import of 1905, were during January a minimum of £8 7s. 6d. for doubles or 24 w.f. material, £9 to £9 2s. 6d. for trebles, and £8 5s. to £8 7s. 6d. for singles, or 20 w.f. material. At the same time, galvanised iron, which had improved £1 10s. per ton in the previous year, were in good demand at £12 2s. 6d. to £12 10s. per ton f.o.b. Liverpool. The high promise of early January was, however, upset by the general election. By the middle of March the decline in demand had become so pronounced, and the difficulty in securing specifications so serious, that quotations in almost all branches had got down to a sensibly lower level. The whole tone of the April quarterly meeting was disappointing, and gas tube strip was reduced 10s. per ton, the basis becoming £7 and £7 2s. 6d. Unmarked bars—ordinary merchant qualities—fell to £6 15s. and £7 per ton; black sheets, doubles, to £7 10s.; and trebles to £8 2s. 6d. and £8 5s. per ton. The second quarter of the year showed no improvement, demand and specifications being a lot worse, and just prior to the July quarterly meeting the Staffordshire marked bar firms took off the 10s. they had added at the commencement of the year, and the "standard" again became £8 10s. Singular to relate, it was almost immediately after this that the present boom with its since remarkable prices set in.

Last January Pig Iron Prices.

Staffordshire pig iron opened the year as follows:—Common forge, 57s. 6d.; part-mines, 62s. 6d. to 63s. 6d.; all-mines, 65s. to 70s.; and best all-mine sorts, 90s. to 92s. 6d. per ton. Northampton grey forge iron was 61s. 6d. to 62s. 6d. per ton, delivered Midlands; Derbyshire, 62s. 6d. to 64s. 6d.; and North Staffordshire best qualities, 66s.; and second sorts 62s. 6d. to 63s. 6d. per ton. These prices have now been nearly recovered.

Pig Iron Closes the Year.

How great has been the advance in the last six months of the boom will be seen when it is stated that at the July quarterly meetings the minimum was touched, as here:—Staffordshire common forge, 46s. to 47s. 6d. per ton; part-mines, 47s. 6d. to 49s.; all-mines, 60s.; and best all-mines, 85s. to 90s. per ton. Northampton forge pigs were down at 46s. to 47s. 6d., delivered Midlands; Derbyshire iron, 48s. to 50s.; and North Staffordshire best qualities, 62s. 6d.; and second sorts, 49s. to 50s.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, December 27th.

Lancashire Pig Iron in 1906.

THE pig iron trade scarcely opened so prosperously as was anticipated from the closing weeks of 1905. Lancashire opened at 64s., and closed at the end of January at 65s.; Derbyshire advanced 6d.—67s. 6d. to 68s.; Lincolnshire remained stationary at 61s. 6d. Cleveland showed little change at 62s. 4d., closing 6d. higher, while hematite ruled weaker, declining from 80s. to 78s. Confidence seemed rather shaken, and an opinion was expressed that there seemed to be no probability of a demand for foundry iron springing up for the States. Seeing that a few years before this had been "dumped" down on the dockside at Salford by thousands of tons, and cleared practically at any price, there was something to justify the prediction. But the "boom" set in "on the other side," and during the three closing months of 1906 there have been heavy sales of Scotch iron both to the States and Germany, whose own domestic requirements were insufficient to meet the demand for crude iron. Indicative of the movement of the market in January, warrants fell on the Glasgow Exchange from 52s. 8½d. to 48s. 5d. "Bear" tactics were evidently predominant. Cleveland iron was cheaper than most other makes by some shillings per ton. Prices became weaker generally. Lancashire No. 3 showed no change, but Cleveland dropped 5s.; hematite, 4s.; Derbyshire, 2s.; and Lincolnshire, 1s. 6d. per ton. It is noteworthy that in 1905 Lancashire had touched 52s. 6d.; Derbyshire, 51s. 6d.; Lincolnshire, 49s. 6d.; and Cleveland, 56s. 4d. March was a disappointing month in the iron trade. While warrants appeared to be fairly steady, Lancashire fell from 65s. to 62s. 6d.; Derbyshire, 61s. 6d. to 58s.; Lincolnshire, 60s. 6d. to 56s. 6d.; Cleveland was rather quiet, but closed practically unchanged. The Lincolnshire Pig Iron Association declared three reductions during the month, but local merchants in some instances, having large holdings, adopted a "cutting" policy and effected sales at about 1s. per ton under the Association's official limit. April brought little relief. Indeed, there was a weakness in many respects. Lancashire fell from 63s. to 61s.; Derbyshire, after registering 1s. to 1s. 6d. per ton lower, closed unchanged at 58s. 6d. Lincolnshire showed even a greater fall, registering 57s. 6d. at the opening of the month, and after dropping to 54s. 6d., closed at 56s. Cleveland did better, ranging from 56s. 10d. to 58s. 4d. A comparatively large demand sprang up from Germany in May and prevented any serious fall in prices as a result of the increased output of crude metal. The market showed little change. Lancashire, Cleveland, and Derbyshire closed at the rates current at the beginning of the month, while Lincolnshire was 6d. per ton lower. The main feature of the trade in June was the strong German demand, coupled with comparatively few fluctuations in warrant prices. Locally, also, the previous month's quotations were repeated; though Scotch fell off somewhat, hematite iron remained steady. In July the American demand, which has been such a striking feature of the closing months of the year, was foreshadowed by persistent inquiries, especially for Cleveland and Scotch iron, and there were continued shipments to Germany. Locally demand, however, was far from good. Lancashire was 6d. lower, say, 60s.; Derbyshire, say, 1s. 6d. lower, at 56s.; Lincolnshire remained unchanged, whilst Cleveland was 6d. dearer. Scotch prices suffered considerably. In August, however, came a return of the swing of the pendulum, followed by a sharp rise in most makes of pig iron. Lancashire went up on spot from 60s. to 62s.; Derbyshire, 56s. 6d. to 59s.; Lincolnshire, 56s. to 58s.; and Cleveland, 59s. 10d. to 62s. 10d. Scotch makes shared in the advance, but only in a limited degree. There was considerable demand in this district, and the American demand has developed into a pronounced "boom," and at the close of the year began to take a definite form. Scotch iron appeared to enjoy the preference and advanced about 1s. per ton in consequence, while Lancashire and other makes were 6d. to 1s. per ton dearer. The two closing months of the year, as already indicated, were of a more or less excited character, and prices of most sorts, especially Scotch and Cleveland, advanced considerably, coupled with shortage. All through this period prices were nominal. The closing figures were:—Lancashire No. 3 foundry, 64s.; Lincolnshire, 65s. 6d. to 66s. 6d.; Derbyshire, 67s. 6d. to 68s. 6d.; Staffordshire, 66s.; Middlesbrough, open brands, 71s. 10d. to 72s. 4d. Scotch: Gartsherrie, 78s. 6d.; Glengarnock, 77s.; Eglinton, 75s.; and Dalmellington, 75s., delivered Manchester.

The Engineering, &c., Trades.

In the engineering and textile machinery trades there is only one tale to be told, that of continued prosperity throughout the year. Machine tool makers have been unusually busy, and the prospects forward are good. Thanks to the work of the Conciliation Committee, any labour difficulties have been successfully grappled with, and harmony has been re-established between employer and employed.

The Lancashire Coal Trade.

The most important feature of the trade during the last twelve months has been the re-establishment of the Conciliation Board for the federated districts for another period of three years, and in view of a rising market an advance will be made in the miners' wages for the first "making-up" day in January. It is fully expected that in addition to the advances made in Lancashire during the past twelve months an advance of 10d. to 1s. per ton will be made on all kinds of coal from January 1st.

BARROW-IN-FURNESS, December 27th.

The holidays have somewhat interfered with trade during the week, but there has been no indication of the demand having been in any sense lessened. Indeed, commercial men made all the arrangements beforehand with reference to the holidays in buying for forward delivery wherever it has been possible to do so, and thus any inactivity in the market during the last few days cannot be taken to reflect any weaker tone. The attitude of the market is indeed strong, and it is known that consumers want to fix up delivery engagements of some magnitude during the coming year. Whether they will be able to do so remains to be seen, as the output of the district is known to be below the demand of users. This will probably mean an increase in prices. Quotations this week are much the same as those of last week, mixed Bessemer numbers being at 81s. net cash f.o.b., and warrant iron at 80s. 6d. net cash sellers. Makers will not, in many instances, sell at 81s., as they are so well off for orders, and have, in fact, orders in hand for a large bulk of iron of special qualities which are not influenced materially by the ups and downs of the market for ordinary brands of hematite iron. Stocks remain steady at 72,955 tons, and it is not thought probable they will be materially increased. Makers hold only small parcels of the different classes of iron they manufacture. There are thirty-eight furnaces in blast. There is a good trade doing in ferro-manganese, spiegeleisen, and charcoal iron, and it is likely to be maintained. The trade in native iron ore is very busy, and a considerable number of orders is in the market, but raisers are difficult to deal with even with the high prices now ruling, 18s. per ton net at mines for good average sorts. Foreign ores are at 23s. per ton net at West Coast ports, and a good business is being done even at the latter figure. There are practically no stocks of local ore, and the demand for inferior qualities is improving.

Steel.

The local steel works have been closed during the week, but it is anticipated another start will be made next week. There is not, however, a good demand either for rails or shipbuilding material, the two principal steel products of the district. Rails are especially quiet, and the demand for plates is slow. Merchant steel is neglected, and the mills in this department have been indifferently employed for a considerable time past. The recent advances in the price of pig iron have led to corresponding advances in the price of steel, and this has had the effect of checking the demand for the latter.

Shipbuilding and Engineering.

Shipbuilders have been expecting new orders during the past few weeks, as their yards are more short of work than at any time during the past ten years. Competition is, however, very keen, and some close cutting has taken place lately. Marine engineers are quiet, but all other departments of engineering are very busy.

Shipping and Coal.

Shipping statistics are not available this week. Coal very firm.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Coal Trade.

SHOULD the present winterly weather continue, the re-opening of the collieries after the usual "play" will see an active call for coal for house purposes. The fogs which prevailed last week, and for some time previous, have interfered even more with steam than house coal deliveries, restricting the supplies received at Hull and Grimsby. The shortage of wagons, of which there has been so much complaint heard from colliery proprietors and local merchants, is pretty certain to be felt again in the early part of the coming year.

Miners' Wages and Coal Prices.

With the granting of 5 per cent. advance to miners in the first month of the New Year, there is an impression that prices for all classes of coal will be increased. This impression is strengthened by the active condition of the trade, which is held, by those concerned in the supply, to justify an upward movement. In several instances merchants have received advices from collieries to raise their price lists for house fuel next month. The movement, however, is not at all general; but with a continuance of snow, such as we are now experiencing, the higher rates would soon be easily obtained. Before the pits were set down for the accustomed holidays, good Silkstone coal made up to 12s. 6d. per ton, and secondary samples from 10s. to 10s. 6d. Barnsley thick seam house coal, in the best quality, was at 10s. 6d., secondary sorts fetching 8s. 9d. to 9s. per ton. Household nuts actively called for at 8s. to 8s. 3d. per ton in owners' wagons at the pits. Confidence is expressed in colliery circles that the advance of 1s. per ton sought in steam coal will be effected all round. For manufacturing fuel the demand has recently been so strong that contracts for next year can only be placed at higher prices than rule with those now expiring, and in some instances consumers are restricting their arrangements for supplies to six months.

Hematite Irons.

During the year the values of hematites, both West and East Coast, have fluctuated rather less than in former seasons. An advance was recorded in pig iron generally at the end of 1905. That advance has been sustained with very slight variation during the year, which is closing with prices higher than they have been since 1900. West Coast hematite on March 31st was at 75s. per ton; on June 30th it was slightly lower, being quoted at 74s. 6d. per ton; but the price on the 21st December had risen to 90s. per ton. For East Coast the price on the 31st March was 74s. per ton; on 30th June 72s. per ton; and on 21st December 86s. to 87s. per ton. These quotations are for hematites delivered in Sheffield and Rotherham, less 2½ per cent. in the case of West Coast and net in respect of East Coast.

The Cause of the Iron "Boom."

The large demand for export has been undoubtedly the great factor in advancing and maintaining values. For the United States and Germany the consignments have been remarkably heavy. The activity in the American and German markets removed the competitive element from the home market, which, having more to do in consequence, has itself been proportionately larger in its consumption. The end of the year finds the Lincolnshire and Derbyshire ironmasters booked well into the New Year.

Steel.

This has been a satisfactory year for steel manufacturers in nearly all directions. The iron market, of course, caused a rise in value of steel; but prices of finished steel have not advanced in proportion to the rise in raw material. There has been an active business both on home and foreign account, with a cheerful outlook for the immediate future. The demand for high-speed tool steel in the United States, Germany, and other distant markets has been larger than ever.

Military, Marine, and Railway Material.

The close of 1905 found the Sheffield armour plate works completing contracts previously placed by the Government. The Naval Programme of 1905-6 left unplaced the orders for three cruisers requiring some 5000 tons of armour. This work was given out early in 1906, and the Sheffield firms had their share of it. Some foreign requirements in shipbuilding were added. The prospect for 1906 is more encouraging.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

THOUGH, on account of the holidays, there has been little buying of pig iron this week, the market must be described as favourable in all respects to makers, and prices have improved, having recovered from the slump which was last week brought about solely by the operations of speculators, who were profit-snatching. It is true that this week stocks will be increasing at a rather rapid rate, but that was looked for. The works of the majority of consumers of pig iron were closed this week until Thursday, and the same arrangement will obtain next week, while the production of pigs will go on nearly at the usual rate. Several of the furnaces are on slack blast this week, and will be next, because, on account of the holidays, there is a short supply of coke and ironstone. Makers are well off for orders for execution during the first half of next year, and it seems probable that that will be a busier time even than the half-year which is now closing has been. The price of Cleveland warrants, which was as low as 60s. 8d. cash one day last week, has risen to 62s. 4d. this week, which is 1s. below the best price of the year, that being reported on the 12th inst. Producers have raised the price of No. 3 Cleveland pig iron to 63s. per ton, and have not only quoted, but have also realised it. No. 4 foundry is at 62s., and No. 4 forge at 61s. The supply of Nos. 4 foundry and forge, and also of mottled and white, has for some time been scarcely equal to the requirements, but will be increased over the holiday period, when the furnaces in many cases turn out more of the lower qualities of iron.

American and German Demands for Pig Iron.

A lull is now reported in the demand from America for Cleveland pig iron; probably the prices are considered too high. Advices from the United States this week state that Cleveland iron delivered there is now as high as American iron, and there is no advantage in buying it just now. There is still no lack of inquiries received in this district for Cleveland pig iron, but orders do not follow. The shipments, however, are going on briskly to Philadelphia and Baltimore.

Hematite Pig Iron.

Makers of East Coast hematite pig iron are even better off than the producers of ordinary Cleveland pig iron, and their quotations have steadily gone up since last August, when they were accepting 64s. 9d., and now the figure is 81s. 6d., a continuous increase of 16s. 9d., whereas No. 3 Cleveland has risen 14s. 9d. this year, the minimum for it also being in the summer. Hematite iron is relatively the dearer, for it is 18s. 6d. per ton above No. 3 Cleveland pig iron, whereas the usual difference is 10s., and at one time last year it was only 3s. 9d. dearer. Rubio ore is up to 23s. 6d per ton c.i.f. Middlesbrough, the minimum of the year being 19s. 4½d. in July. Considerable purchases have been made this month at 23s. 6d. The consumers here have held out long against the higher prices, but they have had to give in, as there is such a pressing demand for Rubio ore, not only for British, but for German and American consumption. The imports of foreign ore into this district have this year been the largest on record; into Middlesbrough alone 1,850,000 tons are estimated to have been received.

Stocks of Pig Iron.

This week stocks in Connal's stores are increasing, but that was expected when consumers' works are stopped, and blast furnaces go on working. In Connal's no iron except Cleveland is now held, and of that all but 19,837 tons are of No. 3 quality, the total quantity held being 539,605 tons. That is 10,342 tons decrease this month, and over 210,000 tons less than in March last, when the largest quantity on record was stored.

Manufactured Iron and Steel.

Most of the finished iron and steel works have been closed during the first half of this week, and some are idle the whole week. It is believed that early in the new year further advances will be decided upon, especially as the cost of materials has gone up so much. Steel ship plates are now at £7 10s; iron ship plates at £7 15s.; steel ship angles at £7 2s. 6d.; steel joists at £6 17s. 6d.; steel bars at £7 10s.; iron bars £7 15s.; steel sheets at £8 10s.; and corrugated and galvanised sheets £13 5s.; all less the customary discount. Heavy steel rails are at £6 10s. net f.o.b.

Platers' Strike on Teesside.

Contrary to general expectation, the strike of the platers on Teesside and at the Hartlepools, which is now in its ninth week, has not ended. The employers and the representatives of the men have had seven lengthy conferences, but have been unsuccessful in adjusting their differences, and now that Christmas is over the dispute may drag on for several weeks longer. Hitherto the shipbuilders have been able to keep their yards going without the platers, but that cannot much longer continue. In the meantime there is great distress among those thrown out of employment by the strike, such as the helpers. The holidays, too, at the yards are being prolonged. The platers refuse to accept the new prices that the employers propose, as they hold that these would mean a very serious reduction in their earnings.

Shipbuilding and Engineering Output.

The shipbuilders have had a very good year, and one firm in the district has turned out the largest tonnage of vessels in the United Kingdom—Messrs. Swan, Hunter and Wigham Richard-

son, Limited, of Wallsend-on-Tyne, whose output is 126,000 tons; the second place is taken by another North-country firm—Messrs. William Doxford and Sons, Pallion, Sunderland, with 106,000 tons.

Coal and Coke.

The demand is satisfactory, and it is believed that next year will be one of the best on record for the coal trade. 1906 has been an excellent time, as is shown by the increase in the wages of the miners, 5 per cent., and now it is decided that other 5 per cent. is due to them on January 1st. Latterly there has been some dissatisfaction about the extent of the advances which the Durham Coal Trade Conciliation Board have awarded, and considerable numbers of the miners have got up an agitation for the abolition of the Board. They carried a resolution to that effect at the meeting of the Miners' Executive Council, and the matter is to be referred to the whole body of miners. After the advance that is now coming due it is probable that the agitation will cease. The prices of coal and coke are the best that have been reported since 1900. Coke is very scarce and dear, and supplies have been obtained from South Yorkshire by some of the ironmasters. Best steam coal has risen to 12s. 3d.; steam smalls to 8s.; best gas coals to 12s.; coking coal to 12s.; and medium coke to 22s. 6d. per ton for next half-year's delivery.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General State of Trade.

WORK has been carried on with great activity this week throughout the manufacturing districts. There was no stoppage for Christmas, but the works will all be closed at the end of the present week for the New Year holidays.

The Warrant Market.

There has been comparatively little doing this week in pig iron warrants. The market was closed on Tuesday and Wednesday, owing to the Christmas holiday. Previous to its close Cleveland warrants were done from 62s. 2d. to 62s. 4½d. cash, 62s. 7d. to 62s. 10½d. one month, and 63s. 3d. for delivery in three months. Cumberland hematite was at 80s. 9d. to 81s. Scotch warrants, 67s. 6d., and standard foundry pig iron, 61s. 7½d. per ton.

Output and Stocks of Pig Iron.

There are 40 furnaces making hematite, 44 ordinary, and 6 basic iron, the total of 90 furnaces thus blowing in Scotland comparing with 91 at this time last year. The stock of ordinary iron in the Glasgow warrant stores shows a reduction of 155 tons, and now amounts to 5456 tons, while there are 4000 tons of foundry pig iron also in store, the whole stock thus amounting to 9456 tons.

Prices of Pig Iron.

Since last report prices of makers' iron have been strong, and in one or two cases further advances have been made in amounts varying from 6d. to 3s. 6d. per ton. G.M.B., No. 1, is quoted at Glasgow 73s.; No. 3, 70s.; Carnbroe, No. 1, 75s.; No. 3, 71s.; Clyde, No. 1, 77s.; No. 3, 72s.; Gartsherrie and Calder, Nos. 1, 77s. 6d.; Nos. 3, 72s. 6d.; Langloan, No. 1, 79s.; No. 3, 74s.; Summerlee, No. 1, 81s.; No. 3, 73s. 6d.; Coltness, No. 1, 86s.; No. 3, 73s. 6d.; Glengarnock, at Ardrossan, No. 1, 77s.; No. 3, 72s.; Eglinton, at Ardrossan or Troon, No. 1. 73s.; No. 3, 70s.; Dalmellington, at Ayr, No. 1, 75s.; No. 3, 70s.; Shotts, at Leith, No. 1, 77s. 6d.; No. 3, 72s. 6d.; Carron, at Grangemouth, No. 1, 80s. 6d.; No. 3, 73s. 6d. per ton.

Foreign Demand for Pig Iron.

The inquiries for pig iron from America, although not so pressing as a few weeks ago, still continue and there is a prospect of a renewal of business immediately after the holidays. Canada is buying Scotch pig iron as well as the United States, and the inquiries from the Continent are such that further business is likely to result. Orders are also coming to hand from Japan, Australia, and elsewhere. On the other hand, it is worthy of note that some Austrian pig iron makers have been endeavouring to contract for sending pig iron from that country to the Clyde. Whether any considerable business will come out of these negotiations it is yet impossible to say.

Finished Iron and Steel.

The makers of finished iron have been busy working off orders which had to be concluded before the holidays. They report that inquiries are coming from Canada, South America, India, and the Colonies. The position as regards steel is strong, and makers have decided to adhere to the prices established by the recent advance of 10s. per ton. The quotation for shipping plates is thus £7 17s. 6d., and other articles are in proportion. Advances of 2s. 6d. to 7s. 6d. per ton have been made in the various sections of steel sheets, which are now quoted from £8 10s. to £11 per ton. It should be explained, however, that in the case of sheets makers are allowed considerable latitude in quoting, and may not adhere rigidly to these rates in the case of good business being offered them. A further advance has been made in the price of tubes to the extent of 2½ per cent. by the makers reducing their discounts by that amount.

The Coal Trade.

There has been great activity this week in the coal trade. The recurrence of frost and snow has caused a very active demand for household coal, and other qualities have also been going away freely. The shipments are 52,000 tons larger than in the preceding week, and 12,000 tons above those of the corresponding week of 1905.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

State of the Coal Trade.

THE week ending December 22nd was an extremely busy one, and the exports, foreign, of coal, coke, and patent fuel from the ports of South Wales amounted to 536,374 tons, an increase over corresponding period of last year of 78,416 tons. Cardiff exported 387,125 tons of coal, 493 tons of coke, and 12,000 tons of patent fuel. The destinations of the principal cargoes were:—River Plate, thirteen cargoes, totalling over 51,000 tons; Port Said, four cargoes, 21,000 tons; and Venice, four cargoes, 17,000 tons. Newport exported 59,936 tons coal, 315 tons coke, and 2000 tons fuel, Ancona, with 1000 tons, being the principal customer. Swansea exported 43,064 tons coal, 955 tons coke, and 3813 tons patent fuel; eight cargoes, totalling some 9000 tons, for Rouen, being the leading customer. Port Talbot shipped 21,543 tons coal and 4605 tons fuel.

Coal Market, and Latest Prices.

The coal market is very firm. There is now a falling off in buying, and towards the close of the week and beginning of this little business was done, collieries appearing anxious to deal with their present obligations rather than enter into fresh. The latest quotations given out on 'Change, Cardiff, were as follows:—Steam coal: Best, 16s. 6d. to 17s.; best seconds, 15s. 9d. to 16s. 3d.; seconds, 14s. 6d. to 15s. 3d.; drys, 15s. to 15s. 6d.; best washed nuts, 12s. 6d. to 13s.; seconds, 11s. 6d. to 12s.; best washed peas, 11s. 6d. to 11s. 9d.; seconds, 10s. 6d. to 10s. 9d.; best smalls, 10s. 6d. to 11s.; best ordinaries, 9s. 9d. to 10s. 3d.; seconds, 8s. 6d. to 9s. 6d.; inferiors, 7s. 6d. to 8s. Monmouthshire semi-bituminous: 15s. 3d. to 15s. 6d.; best ordinaries, 14s. 9d. to 15s.; seconds, 13s. 3d. to 13s. 9d.; inferior sorts, 12s. 9d. to 13s.; best bituminous household coal, 16s. to 16s. 6d.; best ordinaries, 13s. 6d. to 14s. 6d.; seconds and other kinds, 11s. to 13s.; No. 3 Rhondda, 16s.; brush, 13s. 3d.; smalls, 11s. to 11s. 3d.; No. 2 Rhondda, 12s. 9d. to 13s. 3d.; through, 9s. 6d. to 10s. 3d.; smalls, 7s. 3d. to 7s. 9d.

Patent Fuel, Coke, and Pitwood.

A considerable increase is taking place in the patent fuel trade from Welsh ports. In nine months 1,060,617 tons were exported, showing an increase of 219,997 tons. The volume of trade from Cardiff has been very satisfactory. Latest prices: 15s. 3d. to 15s. 9d. Coke continues to indicate the healthy character of the iron trade. Latest figures: Furnace, 17s. 6d. to 18s. 6d.; foundry, 23s. to 25s.; special foundry, 28s. In pitwood supplies have been above the average. Prices range about 21s. Docks offices closed in greater part until end of week.

Anthracite Coal Trade.

In Swansea, Llanelly, and district a busy condition prevailed, but the only report from Swansea was that all collieries were well occupied; prices remain as last week, and firm.

Advance of Wages at Iron and Steel Works.

It was decided, at a meeting of ironmasters held in Abergavenny on Saturday last, that the audit of accounts for the last quarter warranted an increase of wages, and after due consideration, it was agreed that an advance of 4 per cent. should begin on the 1st of January. This may be expected to give general satisfaction, the advance being much higher than was expected.

State of the Iron and Steel Trade.

A fair degree of animation remains the leading feature, but there will be next to nothing doing this week at the leading works. Rails, sleepers, and fish-plates were worked off in tolerable quantities to complete contracts, 2100 tons going to India from Cardiff, and the same steamer took also 1000 tons coal and 100 tons general. Large consignments continue from Newport to Bristol, and from the same port went a miscellaneous cargo of steel, &c., to Natal and 380 tons of rails to Liverpool. In the matter of imports, pig iron has been coming in from Workington, Grimsby, and Barrow, and one large cargo of steel billets, &c., from New York to Newport, with scrap steel from Newcastle, and 500 tons spiegeleisen. There has been no falling off in iron ore imports. Last week Cardiff imported 21,000 tons, Newport 4000 tons, and Port Talbot 1500 tons. Local demands for tin bars are greatly in excess of supplies. All steel works at Swansea are in full drive. Iron and steel quotations remain the same as last week. No quotations were given out at Swansea this week in time for my despatch. Newport and Cardiff prices for iron ore are as follows:—Rubio, 21s. 6d. to 22s.; Tafna, 22s. 6d. to 23s.; Almeria, 21s. to 21s. 6d.

The Tin-plate Trade.

A great deal of activity was shown last week at all the tin-plate works. This was well indicated by the despatch from Swansea of 87,421 boxes, while the receipt from works totalled 85,620 boxes. Stocks are now at 127,765 boxes. The week's output has consisted of mixed sheets, circular discs, black plates, and ternes. It was reported in Swansea this week that mills will not start early on account of the shortage in tin bars. By arrangement with the Conciliation Board, the Aber Works will be closed, it is reported, for the whole of the week. Nickel silver, weldless tube, spelter, and copper works have all been doing good work. Copper works are not expected to resume until Thursday, and most of the industries will have a broken week. No quotations in tin-plate have been issued this week.

The Swansea Dock Harbour Wages Dispute.

I am pleased to be enabled to report an amicable settlement of the dock dispute. The dredger men will get an advance of 5 per cent., labourers 6½d. per hour for firemen, and 5½d. for ordinary labourers. The total advance is expected to amount to £2000 per annum.

NOTES FROM GERMANY.

(From our own Correspondent.)

Rhenish-Westphalian Iron Business.

THE demand for iron ore, pig iron, and malleable iron has been steadily increasing during the week. At all the works of the district activity is strong and the order books are well filled, and good employment is therefore secured for at least five months.

The Siegerland Iron Trade.

In all the principal departments, but especially in the crude iron industry, a strong activity has continued during the past few weeks, and the present satisfactory condition is likely to prevail for at least some months. In plates and sheets and in sectional iron a steady business is done, and quotations are expected to advance in the spring. The wire rod department is in an excellent condition, and the mills can hardly supply the requirements of their customers. The slow and scanty deliveries in billets is the cause of much inconvenience. A rise of M. 5 p.t. has taken place for drawn wire. This week a meeting of the sheet makers will be held for the purpose of regulating, or rather advancing, quotations. At the general meeting of the Union of German Iron and Steel Masters the want of manganese ore, which is so keenly felt in the iron trade in consequence of stoppages in supplies from the Caucasus, has been introduced. In answer to a request put before the Reichskanzler, the Russian Embassy in Petersburg has promised to take measures to prevent the interruptions and irregularities in the Caucasus Railway.

House Coal in Rising Demand.

Engine fuel has remained in very strong request, both in Silesia and in Rheinland-Westphalia; coal for coke making is exceedingly well inquired for, and scarce in consequence. In coke and in briquettes also consumption is higher than output, and a very marked improvement could be noticed in the house coal trade recently, the sharp frost having induced dealers and consumers to purchase very freely.

Condition of Trade in Austria.

All the reports given of the iron and steel industry are favourable, stating a regular activity to prevail in the principal departments. The scarcity in pig iron is less marked than formerly, Wittkowitz throwing a fair quantity on the market now. Fuel is still scarce, and some ironworks are reported to have made endeavours to secure supplies from Germany. The number of orders coming in, both for raw and for finished iron, continues pretty large. Prospects are fair in the rail trade, about 280,000 q. rails having been ordered to replace old ones. Besides, a contract for 36,000 q. rails for the Trient-Malé line has been given out, and will be divided among the different rail works. Last week brought further advances in quotations, the gas and water pipes having been raised one crown per 100 kilos., while a number of Austro-Hungarian pump makers have advanced the prices for their articles 10 per cent. The Hungarian works resolved upon a rise of 30 crowns p.t. for merchant castings, and for stoves an advance of 7½ per cent. is being contemplated; for gas and water pipes a rise, like that of the Austrian works, is also to take place. The coal trade in Austria, as well as in Bohemia, shows much animation, with an upward tendency in prices for nearly all sorts.

Proposed Steel Convention in Belgium.

From week to week increasing firmness can be noticed in the prices for all descriptions of finished iron, and the slight abatement in demand, so often felt in the last weeks of the year, has not been noticed this year, a very healthy condition prevailing all round. According to the *Moniteur des Intérêts Matériels*, the endeavours to form a Belgian Steel Convention have been satisfactory, and the forming of the said Convention is generally regarded as being sure to take place shortly. Ougrée, Marihaye, Cockerill, Providence, Sambre et Moselle, Angleur, Couillet, Thyle-Château, M. G. Boel, and Espérance-Longwy are to belong to the syndicate, which will be formed for a period of five years. The output of coal is very heavy, and consumption increasing in Belgium.

The French Iron Market.

The scarcity in raw iron and in semi-finished steel rather detrimental to the general iron trade, because producers often are unable to meet the demand of their customers, and also because finished iron makers gain very little when they have to pay such high prices for raw iron and for semi-finished steel. Quite recently, however, prices for finished iron have been tending upwards, and so there is prospect of a more remunerative trade being done after New Year. The condition of the French coal market is very strong and satisfactory.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE Midland Manufacturing Company, Limited, advises us that it has appointed Mr. Harry Chapman, of Preston, late of the Nicholson File Company, to represent it in the London district from January 1st, 1907.

THE Royal Sanitary Institute have now decided to grant Messrs. Birch Killon and Co. its medal for the Fiddian sewage distributor. We understand that this is the first and only award ever made by the Institute for a sewage distributor.

BARRY, HEAD AND CO., of 26, Lombard-street, London, E.C., notify us that on January 1st, 1907, they take up new quarters at 110, Cannon-street, E.C. Their telegraphic and telephonic addresses will remain as heretofore, viz., "Till, London," and "10,692 Central."

AN important extension to the works of the Bull's Metal and Melloid Company, Yoker-on-Clyde, has lately been completed in the shape of a rolling mill for bronze and brass, which is the first of its kind in Scotland. By means of this new adjunct to its business the company will be able to roll bars in these metals of from 4in. diameter downwards. Forged bars have already been delivered up to 9½in. diameter.

ALMANACS, DIARIES, &c., FOR 1907.

W. T. GLOVER AND CO., Limited, Manchester, for the fifth year issues a tear-off sheet almanac for the wall. It covers the period until the end of June only, after which date the almanacs will be issued in midsummer for the full twelve months. On the slips are printed extracts from authorities on electrical matters, and the almanac is got up to represent a roll of cable.—From Edward Wood and Co., Limited, 88, Cannon-street, London, we have received, for the fifth year in succession, a pocket diary, which embraces tables and memoranda which will be useful to all interested in building and constructional engineering. An addition which will be appreciated is an insurance coupon for burglary and accident.—Arthur L. Gibson and Co., 19-21, Tower-street, E.C., send a wall calendar with colour-printed paste-down, which is cleverly executed and diverting.—W. T. Henley's Telegraph Works Company, Limited, send a wall almanac of smart appearance with date cards.—The Electrical Power Storage Company, 4, Great Winchester-street, London, issue the usual useful combination diary and blotting-pad, which is always acceptable.—Henry Simon, Limited, send their customary table or wall calendar, with tear-off day slips and well-chosen mottoes.—W. Wilson Cobbett, Limited, 59, Southwark-street, London, manage to work into a tasteful design of monthly almanac an unobtrusive advertisement of their wares.—A servicoable blotting-pad has been sent us by the Hart Accumulator Company, Limited, Stratford, E.—Messrs. Gent and Co., Leicester, send a rather novel design of wall calendar, on which advertising matter has been discreetly made use of.—S. Rentell and Co., Limited, are issuing again "The Practical Electrician's Pocket-book and Diary." It has been carefully revised, and various additions made, including chapters on electric tramcar notes, electric clocks, condensers, lightning conductors, flame arc lamps, hand rules for ascertaining the direction of currents, &c.

STEAM TURBINES FOR SOUTH AMERICA.—An order has been recently given to the firm Franco Tosi, of Legnano, Italy, for three steam turbines—modified Parsons type—of 12,000 horse-power each. These turbines will be the biggest so far built for land service. They will be installed in a new electric central station in Buenos Ayres, which the Deutsch Ueberseeische Elektrizitäts, Gesellschaft, Berlin, formed with German and English capital—at present M. 72,000,000—is building. Franco Tosi has already supplied for the other plants of this company in Buenos Ayres and Santiago twelve steam engines of 1000 to 3500 horse-power each, totalling to about 19,000 horse-power, besides two turbines of 6000 horse-power each. Another turbine of the same power is in hand.

SCOTTISH NATIONAL EXHIBITION, 1908.—The minimum guarantee of £25,000, without which the scheme for an exhibition in Edinburgh in 1908 would not have been proceeded with, has now been more than subscribed. Including the sum of £1000 guaranteed by Lord Strathcona, the fund now amounts to £26,800 and special endeavours are to be made to raise it to £35,000. The Exhibition—which is mainly to be concerned with Scottish national matters—will be held in Saughton Park, belonging to the Corporation, in the western suburbs of the city. An Executive Committee of fifty, with Sir Robert Cranston as chairman, is now vigorously proceeding with the arrangements. The Committee is about to advertise for three plans for the buildings, and any portions of these which, in the opinion of the Parks Committee of the Corporation, would be of permanent use, are to remain after the Exhibition closes.

CONTRACTS.—The Glasgow Corporation Electricity Department have decided to recommend the Council to place an extension order with Messrs. Willans and Robinson, Limited, Rugby, for a 1700-kilowatt continuous-current turbine set, including the necessary electrical generators and the surface condensing plant. This set will be a second set of this type installed at their St. Andrew's Cross Station.—Five locomotives, three Wilson patent counterflow exhaust gas boilers, and two Oddie Barclay high-speed pumps are among the orders booked by Messrs. A. Barclay, Sons and Co., Limited, Caledonia Works, Kilmarnock, during the last month.—Following the orders recently executed by Messrs. Merryweather for the Venice municipality and the Rio Tinto Mining Company for self-propelling fire boats, we learn that the firm has just received a similar order for Genoa. The new vessel will be one of the most powerful in the world, being fitted with twin screws and pumps of a capacity of over 4000 gallons per minute. The speed will be 10 knots per hour.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS,** *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

27,024. December 27th, 1905.—IMPROVEMENTS IN STEAM GENERATORS, *Charles J. A. Grille, 67, Rue de la Victoire, Paris, France.*

The means hitherto employed in connection with the heating of steam generators of the "Solignac-Grille" type have presented serious defects from the point of view of boiler efficiency due to their special characteristics. The tubes of a Solignac-Grille generator are of such small diameter that it is necessary to set them closely together in order advantageously to utilise the furnace gases. Moreover, the circulation in these tubes by means of regulable nozzles produces, in comparison with other generators, such an intense vaporisation per unit of surface that the tubes are safely cooled. Consequently, the nest of tubes in a Solignac-Grille generator acts, in the presence of the hot gases, in exactly the same way as a fine wire gauze would act and is kept constantly cool, if the firing is forced, or if cannel coal be employed, and the gases will pass through the nest of tubes before having become thoroughly burnt, and become extinguished by contact with the tubes. There are three figures. Fig. 1 is a part sectional elevation. The ignited gases issuing from the furnace are caused to pass towards the rear and around the end of the screen *a*, whereupon they separate into two currents, one of which flows—as shown by arrows 1—directly between the tubes at the back of the nest, and striking baffle *c*, is caused to pass along under it into the free space *i*, while the other flowing—as indicated by arrow 2—along the screen *a* directly into space *b*, escapes the cooling effect

Nº 27,024.

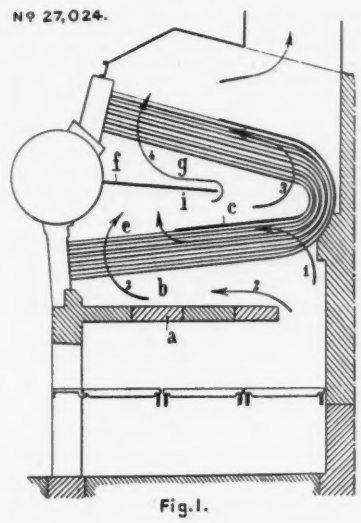


Fig.1.

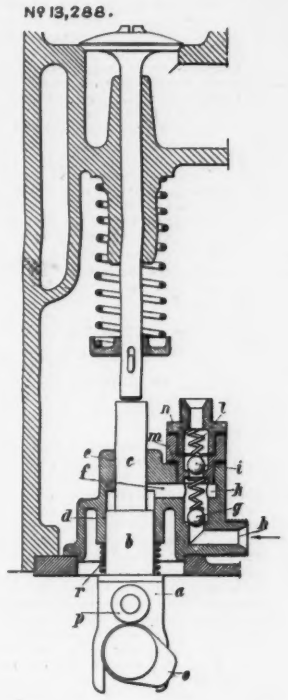
of the tubes until its flow, substantially horizontal, becomes vertical so as to be delivered after passing through space *e* into the space *i* between the two branches of members of the nest of tubes. Since this latter current of gases only passes vertically through the lower member of the nest of tubes it is subjected to only a slight cooling action, and on arriving in space *i* it is still in a state of ignition, and its temperature is, therefore, sufficiently high to re-ignite the gases of the first current which has followed the course indicated by arrow 1, and which have become partly extinguished by reason of their having become cooled by prolonged contact with the tubes of the lower member. The gases thus re-ignited in space *i* then come in contact with baffle *f* and pass around the rear end of the latter and again separate into two currents, one of which flows between the tubes of the upper member as indicated by arrow 3, while the other—as indicated by arrow 4—passes into the space *g*, and rises so as to pass directly through the whole depth of the upper member of the nest of tubes. Thus the upper member of the nest of tubes is heated throughout its length by the burning gases, its rear portion by the stream of gas 3, and its forward portion by the stream 4. This combination of baffles ensures the perfect utilisation of the furnace gases for the regular heating of the two members of the nest of tubes throughout their entire length.—*November 28th*, 1906.

INTERNAL-COMBUSTION ENGINES.

13,288. June 8th, 1906.—IMPROVEMENTS IN OR RELATING TO THE LUBRICATION OF EXPLOSION ENGINES, *Armand Farkas and Joseph Kieffer*, 13, *Rue Taitbout, Paris, France.—Date under International Convention, July 3rd*, 1905.

This invention relates to that method of lubricating explosion engines in which a part of the valve gear, such, for instance, as the end of a valve-operating stem, is used as the plunger of a pump for supplying oil to the various parts of the engine. There is one figure—a sectional elevation. The spindle *a*, controlling the lift of one of the valves, comprises, in its sliding portion, two portions *b c*, of different diameters, moving without any play in the cylindrical parts *d e*, of corresponding diameters, of a socket forming the guide. The inner portion *d* of the socket having the large diameter is connected by a conduit *f* to the seat of a ball valve *g*, held constantly closed by a weak spring *k*, the valve *g* establishing communication between the conduit *f* and another conduit *h* connected to the oil feed tank. Above the valve *g* is arranged a second valve *i*, also applied to its seat by a weak spring *l*. The seat of the valve *i* is constituted by two detachable unions *m n*, enabling the valves *g i* and their respective springs *k l* to be put in place. The outer union *n* is connected by a suitably arranged conduit to the various pipes conveying oil to the parts to be lubricated. A spring *r* is arranged on the part *b* of the spindle *a* in such a manner as to keep a roller *p*, carried by the spindle *a*, always applied against the distributing cam *o*, and, consequently, a suction chamber is constituted between the corresponding differential parts of the portions *b c* and of their guide socket. To each revolution of the cam *o* correspond suction and discharge periods of the fluid between the two valves *g i* and the space *s*, which will result in the fluid drawn in through the conduit *h* being forced through the union *n*

Nº 13,288.



in order to be distributed to the parts to be lubricated.—*November 28th*, 1906.

1805. January 24th, 1906.—APPARATUS FOR THE VOLATILISATION OF OILS FOR INTERNAL-COMBUSTION ENGINES, Sidney C. Smee, Hemingford, Manor-road, Teddington, Middlesex.

This invention relates to an unheated apparatus whereby light or heavy oils can be volatilised, and used in internal-combustion engines. There are four figures. Fig 1 shows a vertical section of the complete apparatus, the upper half *a* being an oil reservoir and feeder, the lower half *m* a volatilisation chamber. Oil is kept at a constant level in the reservoir *a*. Oil is pumped from the fuel tank into the reservoir *a*, in which two tubes, an inlet *b* and an outlet *c*, are provided, the top of *b* being higher than the top of *c*. Through *b* the surplus oil runs back to the fuel tank by means of a pipe provided for same. The reservoir *a* can be emptied when necessary by means of the drain *f*. In the reservoir *a* are two small hollow cylinders, *d* and *j*; *d* is a measuring chamber filled from the reservoir *a* by means of a small hole *e*, above which is provided a suitable check valve *g*. The top end of the cylinder *d* is sealed by means of an adjustable screw *h*, which determines the capacity of *d*. Below the screw *h* is a hole *i* communicating with the second cylinder *j*, which again has an outlet *l* at the bottom,

Nº 1,805.

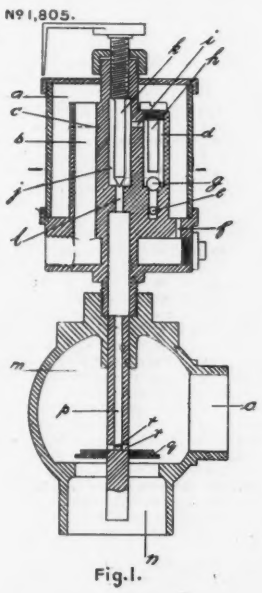


Fig.1.

provided with a valve seat to regulate the quantity of oil that passes down the tube *p*. The screw valve needle *k* is arranged to pass through the top of the cylinder *j*, and has a needle point fitting the valve seat at the bottom. Below the portion *a*, and attached to it, is provided a metal chamber *m*, preferably spherical in form, and provided with two apertures, one *n* for the entrance of air, and the other *o* communicating with the engine combustion chamber. In this chamber *m*, communicating with *j*, is provided a vertical tube *p*, at the bottom of which is a disc, or discs, *q*. In that part of the tube *p* just above the discs *q* are small holes *r* through which the oil flows out on to *q*. The discs *q*, which are fixed, but adjustable, are fitted in a suitable position so as to deflect the incoming air, which thus picks up the oil. On the down stroke of the engine piston oil is drawn from the reservoir *a* by the partial vacuum thus caused, passes through *e*, lifting the check valve *g*, fills *d*, and enters *j*; passing by the needle valve regulator *k* the oil now drops down the tube *p*, flooding the discs *q*. The inrush of air through the aperture *n* picks up the oil, carrying it through *o* by the way of the inlet valve of the engine to the cylinder.—*November 28th*, 1906.

8191. April 5th, 1906.—IMPROVEMENTS IN AND CONNECTED WITH INTERNAL COMBUSTION ENGINES, *Otto Lietzenmayer*, 2, *Tengstr., Munich, Germany.*

In internal combustion engines hitherto known where the fuel is introduced into the working cylinder at the end of the compression by means of air compressed above the compression in the working cylinder, the valve motion for the admittance of the fuel has been so arranged that the fuel and the air necessary for its introduction into the working cylinder have been admitted jointly at the moment when the compression in the working cylinder has reached its maximum. The object of this invention is to provide this type of internal combustion engine with means whereby the valve motion for the admittance of the air is completely separated from the fuel nozzles, so that, for instance, when employing a number of such nozzles, say two, to work simultaneously, only one air inlet valve will be necessary, and the valve motion thus rendered very simple and the two nozzles simultaneous in action. A number

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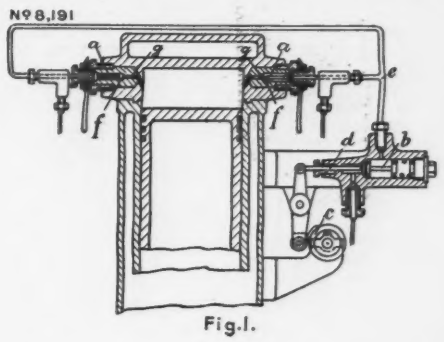

Fig.1.

of nozzles employed in one cylinder not only distribute the fuel better, but can be arranged so as to allow of rendering one or the other inoperative for the purpose of being cleaned without necessitating the stoppage of the engine. The said nozzle may be also arranged to start the engine by compressed air. There are four figures. Figure 1 is a part sectional elevation; *a* are the fuel nozzles, *b* is the air inlet valve actuated by the cam *c* and the spindle *d*. The valve *b* when opened allows the air to pass through the pipe *e* to the two nozzles and force the fuel from the cups *f* through the channels *g* into the combustion chamber, which takes place simultaneously and under the same conditions. Back pressure valves may be employed in the pipe *e*.—*November 28th*, 1906.

ORDNANCE.

933. January 12th, 1906.—IMPROVEMENTS RELATING TO THE BREECH MECHANISM OF ORDNANCE, Carl Holmstrom, 25, Victoria-street, Westminster, and Elias Middleton, care of Messrs. John Brown and Co., Limited, Atlas Works, Sheffield.

This invention relates to gun breech mechanism of the kind in which the breech block is provided with a "de Bange" obturator, and is rotatably mounted in a swinging carrier pivoted at the side of the breech. In this class of breech mechanism there have been employed obturators having little, if any, taper, and lever mechanism whereby, after the block has been angularly displaced to unlock it from the breech threads, the block will be caused to move a short distance in a rectilinear path to remove the obturator from its seat and permit of the block being then swung out of the breech chamber by the carrier. It is the chief object of this invention so to construct the breech that the lever mechanism will exert a powerful rearward pull or toggle-like action on the block during the opening movement which will effectually unseat the obturator, the mechanism being also adapted to operate with equal effectiveness during the inward rectilinear movement of the block and the seating of the obturator. There are six figures. Fig. 1 is an elevation of the breech end of a gun with the improved breech mechanism applied thereto, the parts being in the

Nº 933.

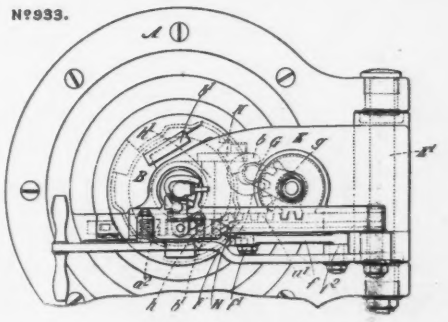

Fig.1.

position they assume when the breech is fully closed. A is the breech end of the gun, B the breech block. There are also an obturator and an obturator pad. E is the swinging carrier and F the breech actuating hand lever. The aforesaid sliding bar is made in the form of a double rack a^1, a^2, one set of teeth engaging in the known manner with a toothed segment *g*, forming part of the crank or arm G, which is on the carrier and which imparts the angular movement to the block through the radial slot *b*. The other set of teeth is at right angles to the set of teeth a^1, and engages with a toothed segment *h* forming part of the pair of cranks or arms H H. These cranks or arms are carried by a vertical shaft h^1 on the carrier and impart the rectilinear movement to the block. Their free ends move in a horizontal plane and have anti-friction rollers which move in the direction of the arrow to engage with the pair of flanges or grooves b^1, b^1 on the rear face of the block and exert a powerful rearward pull on the latter, as aforesaid. The double rack is actuated by a link *f* which is connected at f^1 and at f^2 to the breech actuating lever, which moves about a pivot on the carrier, and in its outward movement brings a tooth or projection against a lug on this carrier, so that the continued outward movement of the lever causes the carrier to swing about its pivot E.—*November 28th*, 1906.

BEARINGS.

16,716B. August 17th, 1905.—IMPROVEMENTS IN AND RELATING TO AIR BEARINGS FOR HIGH SPEEDS, Sebastian Z. de Ferranti, 31, Lindhurst-road, Hampstead.

This invention relates to improvements in air bearings for high speeds, and is especially applicable to spinning, doubling, and like machines. Mr. Ferranti has found in the application of air bearings in textile machinery for high speeds that the power absorbed under such conditions increases more rapidly than the square of the speed. These bearings are generally of the type which rotate about a vertical axis, and are so constructed that a film of air of very small dimensions maintains the rotating part centrally within the standing bearing. As the axis of rotation is vertical, and the drive of such a type as to give practically a uniform torque, it follows that the parts have very little load to

carry other than their own weight, and that due to the drag of the material. Under these conditions the power absorbed becomes a serious factor in the efficiency of the bearing, especially when working at such high speeds. There are five figures Fig. 1 is a sectional elevation of a turbine-driven ring flyer. A running bearing part 1 is inserted between the stationary bearing part *a* and the ring flyer *b*. The ring flyer *b* carries turbine blades *c* at its upper extremity, which are shielded by a ring *d* having holes *e* disposed therein at suitable intervals to allow a free passage for the exhaust. The ring *d* encloses and shields the blades *c* as much as possible, so as to reduce to a minimum the losses due to the fanning section of the blades. The air which forms the working fluid is supplied by the pipe *f* and is discharged through nozzles *g* to operate on the turbine blades *c*. The exhaust from the blades passes to a chamber

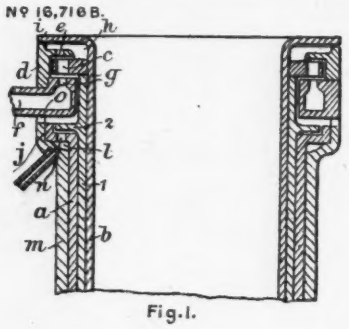

Fig. 1.

h, where it acts on the flange *i* of the ring flyer to support the deadweight thereof. The action of the air on the flange *i* causes it to be lifted sufficiently so as to allow the escape of the working fluid either directly to the atmosphere or to the exhaust trunk, according to the machine. It will thus be seen that the part *b* has its deadweight supported on a cushion of elastic fluid. In order to support the running bearing part 1 in a similar manner, a flange 2 is formed on it which rests in a seat *j* formed on the dished top of the stationary part *a*. Air under a small pressure, say ½ lb. per square inch, is introduced by a pipe *k* into an annular chamber *l* situated between the stationary part *a* and the casing *m*, and is led underneath the flange 2 by holes *n* formed at suitable intervals in the stationary part *a*. The operation of the air on the flange 2 causes it to be lifted and supported, and at the same time allows the air to escape to the exhaust or to the atmosphere by the annular passage *o*.—*November 28th*, 1906.

MISCELLANEOUS.

24,058. November 22nd, 1905. — IMPROVEMENTS IN ELASTIC SUSPENSION DEVICES FOR THE ELECTRIC MOTORS OF TRAMCAR AND LIKE TRUCKS, Montague B. Mountain, Godfrey M. Gibson, and Arthur F. H. Head, Elton Fold Works, Bury, Lancashire.

The motors of electric tramcar trucks, trucks, or bogies are usually suspended in the truck frame by an arrangement at each side of the frame of two spiral springs, one above and the other below the bar on which the motor is suspended, and one (the lower) is adapted

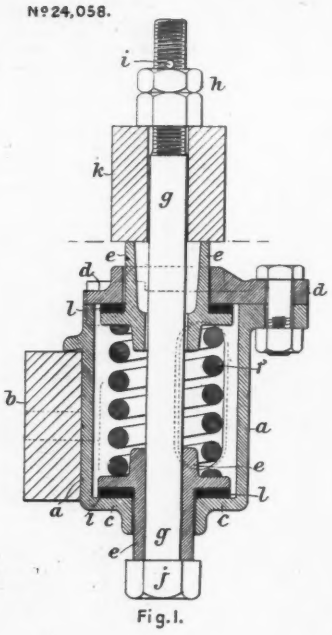

Fig. 1.

to take the weight of the motor, whilst the other (the upper) is adapted to cushion the recoil when starting the motor. The object of this invention is to do away with the upper or recoil spring, which is frequently screwed up until it closes and is of no use, and to cause one spring to act for checking the movements of the motor both upwards and downwards. A further object is to reduce the jar and noise usually present with the old arrangement of springs. There are two figures. Fig. 1 illustrates a vertical cross section; *a* is the casing, preferably of cast iron, and formed with lugs, by which it may be conveniently bolted to the truck frame *b*; *c* is the inturned flange at the other end of the casing, this last-named flange being secured to the casing by bolts and nuts; *e e* are the two tubular bushes, each formed with a flange, and one bush projecting through an orifice in the end flange *c* and the other projecting through an orifice in the plate *d*; *f* is the spring lying between the two bushes, and, by elongation, holding the bushes at the ends of the casing; *g* is the bolt which passes centrally through the casing, flanges, bushes, and spring, and which, at one end, is provided with lock nuts *h* and a pin *i*, and at the other end with a head *j*. The bolt also passes through the usual motor suspension bar *k*, the nuts *h* being arranged either below the casing *a* and the head *j* above the bar *k* or the head *j* below the casing. The weight of the motor is carried by the bar *k*, which, in turn, is carried by the spring *f*, placed in the casing *a* with an initial compression equal to the weight of the motor, so that when in the casing the spring will not be further compressed except with the oscillation or recoil of the motor, and shall always tend to hold the bushes against the casing ends, as shown in the drawing; *l*, *l* are the washers for preventing any jar between the bushes and the end flanges of the casing. The bushes *e*, *e* extend a distance beyond the raised parts of the flanges *c*, *d* sufficient to allow of the maximum compression of the spring downwards or upwards. There are two of the improved suspension devices used, one on each side of the truck frame, the bar *k* being common to both.—*November 28th*, 1906.

24,397. November 25th, 1905.—IMPROVEMENTS IN HYDRAULIC PRESSES, James Leeming, jun., 35, Back Quay-street, Waterstreet, Manchester, and Andrew Greenhalgh, Wallfield, Whitefield, near Manchester.

This invention relates to improvements in hydraulic presses for baling cotton and other fibrous materials, and the object of the improvements is to save time and labour and prevent waste of water in the manipulation of the intensifier, by which the normal pressure in the main or source of supply is increased to any desired pressure in the press. There are seven figures. Fig. 1 is an end sectional elevation. A pair of hydraulic cylinders *a*, *b*, are arranged to work in conjunction with a pair of cylinders or casings *c*, *d*, containing the valves *e*, *f*, for directing the water from the main or source of supply to the intensifier *g* and the press *h*. In the first instance the water flows from the supply through the pipe *i* and through the arrangement of double back-pressure valves in the box *j* to the smaller ram *k* of the intensifier *g*, thereby driving back the larger ram *l*, and forcing the water—at present wholly or partially run to waste or to an accumulator—from the intensifier *g* on through the arrangement of double back-pressure valves in the box *m* to the press cylinder *h* to fill up, and at the same time raising the pressure in the press to, say, about 250 lb. per square inch, obtained from the large ram *l* of the intensifier, the normal pres-

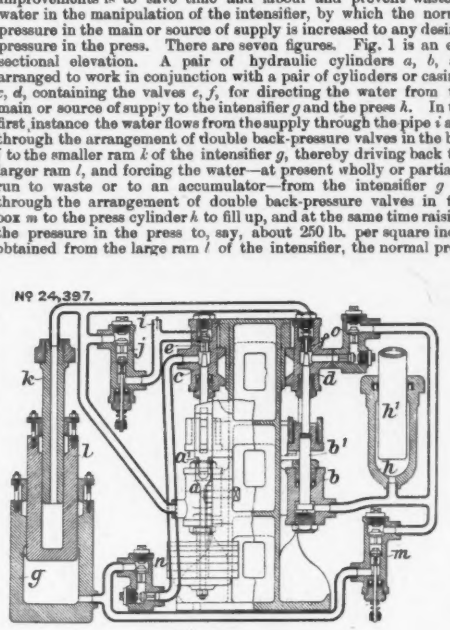

Fig. 1.

sure of the supply upon the small ram *k* being, say, 10 cwt. per square inch. The water, under pressure of 10 cwt., then automatically actuates the ram d^1 of the first hydraulic opening cylinder *a*, and thereby opens the valve *e*, which it controls, and by this action turns the pressure of 10 cwt. from the main or source of supply through the valve *e* and back-pressure valve-box *n* to the opposite end, that is, to the large ram *l* of the intensifier *g*, and simultaneously, through the back-pressure valve-box *m*, raises the pressure in the press cylinder *h* to 10 cwt. The pressure on the large end of the intensifier ram *l* being 10 cwt., and the ratio being six to one, it follows that the pressure from the small end of the ram *k* of the intensifier *g* is increased to three tons, which is locked while the second valve *f* remains closed until the pressure on the other or second hydraulic valve opening ram b^1 and press ram h^1 is raised to 10 cwt. This pressure of 10 cwt. now causes the second valve *f* to open by means of a relief valve against the pressure in the pipes of three tons, and this pressure of three tons is thus automatically turned on through another double back-pressure valve-box *o* to the press, and the bale finished. Where several presses are employed in combination with one intensifier, the pressure of three tons obtained by means of the intensifier can be used without loss of water, to put the final set on all or as many of such presses as the capacity of the intensifier will permit, before the said pressure is relieved, or the action reversed. When the press ram has been released by running out the water from its cylinder *h* in the ordinary way, and the releasing stop, not shown, has been closed, by then opening the pressure stop, not shown, the pressure of three tons immediately falls, and, together with it, the half-ton pressure generating it falls in the ratio of the intensifier rams *k*, *l*. Both the hydraulically-actuated valves *e*, in the arrangement being immediately closed, allow the main pressure to flow as at first, to the small ram *k* of the intensifier, thus again utilising and driving the surplus water from the large ram *l* to the press *h*, instead of running it to waste, and then filling up the press from the source of supply as the press ram h^1 rises, the hydraulically-actuated valves *e* and *f* again open and reverse, and automatically repeat the action.—*November 28th*, 1906.

CATALOGUES.

W. AND T. AVERY, Limited, Soho Foundry, Birmingham.—Catalogue No. 231 of weighing machines, scales, weighbridges of all descriptions.

GLOBE PNEUMATIC ENGINEERING COMPANY, Limited, 150, Queen Victoria-street, E.C.—Illustrated catalogue of Tierney pneumatic tools and appliances.

S. F. EDGE, Limited, 14, New Burlington-street, London.—This is a very artistic book describing the Napier motor car, and some of the feats which it has accomplished.

ROCKWELL ENGINEERING COMPANY, New York. — Several pamphlets devoted to fuel oil burning appliances, annealing, hardening and tempering furnaces, brazing furnaces, &c.

CLARKE, CHAPMAN AND CO., Limited, Gateshead-on-Tyne.—The latest water-tube boiler catalogue is devoted to Woodeson's patent boiler, which has all straight tubes, no screw joints, is easy to inspect and clean, and is a free steamer.

W. N. BRUNTON AND SON, Musselburgh, Scotland.—A small pamphlet has been published by Messrs. Brunton giving concise but detailed instructions respecting the methods of splicing wire ropes, which will be found of much service to many of our readers.

VEREINIGTE MASCHINENFABRIK AUGSBURG UND MASCHINENBAUGESELLSCHAFT NURNBERG A.G., Nurnberg. — This is an admirable album of views of this firm's factories, and also contains a number of illustrations of the various types of engineering work which it has carried out.

SCHUCHARDT AND SCHUTTE, 34, Victoria-street, Westminster.—This firm is issuing a rather striking card advertising Initiandum hack-saw blades. It depicts a workman with a pile of broken blades at his feet hailing the advent of the new saws which are represented marching to his aid.

PALATINE ENGINEERING COMPANY, Limited, 10, Blackstock-street, Liverpool.—This new catalogue of hydraulic apparatus is divided into four sections, and includes particulars of the recent invention of Lord Kelvin, namely, the Kelvin bulk meter. Two of the chief features claimed for this meter are its accuracy at all flows, and its very slight loss of head.

FRANK REDDAWAY, Manchester.—"Practical Notes on Belting and Belt Driving" is the subject of a book of which four editions have been called for. Since the third edition, Mr. Reddaway has had further tests made of the "Camel" brand belting for ascertaining as far as possible the coefficiency of friction and modulus of elasticity of the belt, and the results are given.

VULCANITE, Limited, 118, Cannon-street, London.—This new catalogue embodies a number of illustrations of recent works and demonstrates the varied characters of the buildings upon which vulcanite roofing is used. It is claimed that this material lends itself particularly for the covering of concrete flat roofs, as it makes an absolute water-tight job of any concrete surface, even if the latter happens to show slight cracks of permeability, the cracks being frequently due to expansion in the concrete.

ALBANY ENGINEERING COMPANY, Ossory-road, Old Kent-road, London.—This pamphlet describes the Albany rotary water-sealed pump with patent hydraulic grooves. The most important feature of these pumps is the fact that slips and leakage have been eliminated by the introduction of groove cuts along the face and edges of the teeth, so that in rotating a body of water lodges in the grooves, forming an absolute sealed water-tight joint or cushion between the casing and the rotating rollers, thereby producing an efficient vacuum.

LOUDON BROTHERS, Limited, Clyde Engineering Works, Johnstone, N.B.—The 1907 edition of this firm's catalogue of machine tools is a massive publication divided into five sections—lathes and vertical boring mills; planing, shaping, and slotting machines; horizontal boring, drilling, and tapping machines, screwing, milling, and wheel-cutting machines; and hammers operated by steam, air pressure, riveting, flanging, and sawing appliances. The illustrations are very effective, the letterpress clear, and the printing good.

CHAS. W. COOK, Coupland-street, Manchester.—Circular describing the Berthelot-Mahler bomb apparatus for determining the calorific values of coal, coke, oils, &c. The bomb itself, of some 650 c.c. capacity, is made of mild forged steel of the highest quality. The inside surface is coated with a special enamel to protect the steel against corrosion. The cover, the inside surface of which is thickly gilt, is connected by a powerful hexagon nut and spigot joint, whilst the valve for admission of oxygen is of an improved type, which has been in successful use for many years in other high-pressure apparatus made by the firm. The insulated plug and supports for the crucible, &c., are made of solid platinum, although nickel can be substituted, at a marked reduction in cost, if desired.

THE *Reichsanzeiger*, Berlin, reports that an Exhibition of motors, motor cars, motor boats, as well as accessories and designs, will be held in Bergen from 5th to 14th July next. In connection with it, a conference of the Norwegian, Swedish, and Danish Fishing Industry will be held. The exhibition is to be Scandinavian, but foreign motors will be admitted if exhibited by Scandinavian or Danish agents. The address is: Motorudstillingskomiteen, Bergen, Norway.

AN experimental automatic interrupter, described in the *Electrician*, consists of two thin rods of carbon, about 1 centimetre apart, and parallel to each other. They are connected with the two poles of an 8-volt accumulator. If a third similar carbon rod is placed across these two, sparks can be seen at the points of contact, and a loud sound is heard. This proves the presence of periodic functions. If the primary of an induction coil is put in the circuit a rapid succession of sparks pass between the secondary terminals. The combination of these three carbons, therefore, forms an automatic interrupter. If the third carbon is placed in such a position that it rests on one of the parallel carbons and just touches the other, the sparking occurs only on this loose contact, and the interruptions are more frequent. At the same time, the third carbon shows a remarkable tendency to oscillate in a direction perpendicular to its longitudinal axis. The phenomenon is said to be probably caused by alternate expansion and contraction caused by heating and cooling.

END OF VOL. CII.

GENERAL LIBRARY,
UNIV. OF McGil.
JAN 11

The Engineer.

Registered as a Newspaper

OFFICE FOR ADVERTISEMENTS AND PUBLICATION, 33, NORFOLK STREET, LONDON, W.C.

VOL. CII.—No. 2661] LONDON: FRIDAY EVENING, DECEMBER 28, 1906. [PRICE SIXPENCE

International Seismological Association.

The Permanent Commission of the International Seismological Association has resolved to hold a COMPETITION for the CONSTRUCTION of a SEISMOMETER, recording the movements of the soil during earthquakes which have their origin near the place of observation.

The instrument must satisfy the following conditions:—

1. It must be able to register both horizontal and vertical movements.
2. It must be of simple construction. The record must give a magnification of not less than 40 to 50 times.
3. The selling price of the instrument, with the registering apparatus, must be as low as possible (£15 approximately).

Four prizes are offered, having the respective values of 1000 Marks, 700 M., 500 M., and 300 M. (approximately £50, £35, £25, and £15).

The instruments must be sent at the expense and risk of the competitors to the Vice-President of the Association, Dr. J. P. Van der Stok, De Bilt, Netherlands, before September 1, 1907, and are to be exhibited at the general meeting of the Association, which will be held at the Hague during the month of September.

The efficiency of the instrument will be investigated at the Central Bureau, Strasburg, and the awards will be determined by a jury composed of five seismologists chosen by the Permanent Commission. The results will be announced at Easter, 1908.

For further particulars apply to Professor C. GERLAND, Director of the Central Bureau, Strasburg, I.E. 1958

NOTICE.

The British Oxygen Co., Ltd.

(formerly known as BRINS OXYGEN CO., Ltd.), the owners of the Linde and Hampson Patents for the Manufacture of Liquid Air and the Separation of Oxygen and Nitrogen from Liquid Air, HEREBY GIVE NOTICE that they have commenced legal proceedings against the Liquid Air Power and Automobile Co., of Great Britain, Ltd., to restrain the infringement of the said patents.

As owners of the above patents, the British Oxygen Co., Ltd., claim exclusive rights in the commercial production of Liquid Air and the Separation of Oxygen and Nitrogen thereby. They will take proceedings against all persons infringing these rights 1132

Bedford Grammar School.

ENGINEERING SIDE.

Exhibitions. Head Master's Nominations.—For Syllabus of the Three Years' Course, as approved by the Authorities of the leading London Engineering Colleges, apply, SECRETARY, Grammar School, Bedford. 679

King's College, London

(UNIVERSITY OF LONDON).

FACULTY OF ENGINEERING AND APPLIED SCIENCE.

LENT TERM COMMENCES TUESDAY, JANUARY 8TH.

PROFESSORS:

ENGINEERING: DAVID S. CAPPER, M.A., M. INST. C.E., M.I.M.E.; H. M. WAINFORTH, A.M. INST. C.E., A.M.I.M.E.; M. CURRY, M. INST. C.E.

ELECTRICAL ENGINEERING: E. WILSON, M.I.E.E.

NATURAL PHILOSOPHY: H. A. WILSON, M.A., D.Sc.; H. S. ALLEN, M.A., B.Sc.; J. NICOL, B.A., B.Sc.

BUILDING CONSTRUCTION: R. ELSEY SMITH, A.R.I.B.A.; W. WILSON, PH.D.

CHEMISTRY: J. M. THOMPSON, F.R.S., F.I.C.; H. JACKSON, F.I.C.

MATHEMATICS: S. A. F. WHITE, M.A.; B. DALE, M.A.

METALLURGY: A. K. HUNTINGDON, A.R.S.M., M.I.M.E.

GEOLOGY & MINERALOGY: H. G. SEELEY, F.R.S.

EVENING CLASSES

are held for Civil, Mechanical, and Electrical Engineering Workshop Practice, Architecture and Building Construction, Drawing, Metallurgy, Mathematics, Physics, and all Science Subjects.

ADVANCED EVENING CLASSES.

Civil Engineering, Mechanical Engineering, Electrical Engineering.

For Prospectuses and all information apply to—

THE SECRETARY.

King's College, Strand, W.C. 1990

ELECTRICAL ENGINEERING.

The Electrical Standardising,

TESTING, and TRAINING INSTITUTION (Established in 1899).

FARADAY HOUSE,

64-70, SOUTHAMPTON-ROW, LONDON, W.C.

Chairman—The Rt. Hon. the Earl of CRAWFORD, K.T.

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Affords a thorough PRACTICAL and THEORETICAL TRAINING in MECHANICAL and ELECTRICAL ENGINEERING for the sons of gentlemen. It is connected with a large number of engine builders, electrical manufacturers, power supply stations, and railways, to provide its students with practical experience.

Applications are constantly being received for Electrical Engineers. Next Term begins January 7th, 1907. 1779

City and County Borough of Belfast.

MUNICIPAL TECHNICAL INSTITUTE.

The Library and Technical Instruction Committee invite APPLICATIONS for the following POSITIONS:—

(a) ASSISTANT LECTURER and DEMONSTRATOR, Mechanical Engineering Department. Salary £180 per annum.

(b) ENGINEERING WORKSHOP INSTRUCTOR. Salary £150 per annum.

Particulars of the duties and conditions of appointment and forms of application may be obtained, either personally or by letter, at the office of the Municipal Technical Institute, Belfast.

Applications, on the special form provided for the purpose, must be lodged with the undersigned not later than noon on Tuesday, 15th January, 1907.

Applications should be accompanied by copies of three recent testimonials (original testimonials must not be sent).

Canvassing will be a disqualification.

FRAS. C. FORTH, Assoc. R.C.Sc. I.,
Principal, Municipal Technical Institute, Belfast.
1962

East Indian Railway.—The East

Indian Railway Company is prepared to receive TENDERS for the SUPPLY and DELIVERY of:—

(1) DECK SPANS (from 4ft. 6in. to 31ft. 5in. in the clear).
(2) SPRING STEEL.
(3) METALS (Antimony, Brass, Copper, Lead, and Zinc).
(4) CANVAS, &c.
(5) FIREBRICKS.
(6) PAINTS, &c.
(7) LAMPS, LAMP FITTINGS and MISCELLANEOUS GLASS.
(8) BOLTS, RIVETS, &c.,

as per specifications to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Deck Spans," or as the case may be, not later than Twelve o'clock noon on Wednesday, the 9th day of January proximo.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.

For each specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By order,
C. W. YOUNG,
Secretary.

Nicholas-lane, London, E.C.,
22nd December, 1906. 1991

Bridgwater Rural District Council.

WATER SUPPLY.
CONTRACT No. 1.

The Bridgwater Rural District Council are prepared to receive TENDERS for the LAYING of 8556 YARDS or thereabouts of CAST IRON PIPES, 2in. and 3in. in diameter, and other WORKS appertaining thereto, including the Construction of two Concrete Piers, on the banks of the River Parrett, in accordance with the drawings, specifications and instructions of their Engineer, Mr. W. A. Collins, Binford-place, Bridgwater.

Drawings may be seen and copies of the specification and bill of quantities obtained at the Rural District Council Offices in Bridgwater, on and after the 1st January next on payment of One Guinea, to be returned on receipt of a bonâ fide Tender.

Sealed Tenders, addressed to me and endorsed "Tender for Pipe Laying," are to be delivered by post or otherwise at the Rural District Council Offices in Bridgwater, at or before noon of Monday, January 14th, 1907.

The Council do not bind themselves to accept the lowest or any Tender.

T. M. REED,
Solicitor and Clerk to the above Council.
Bridgwater, December, 1906. 1955

Bridgwater Rural District Council.

WATER SUPPLY.
CONTRACT No. 2.

The Bridgwater Rural District Council are prepared to receive TENDERS for about 150 TONS of CAST IRON PIPES, 3in. and 2in. in diameter, and other Castings, to be made in accordance with the specification of their Engineer, Mr. W. A. Collins, Binford-place, Bridgwater.

Persons desirous of tendering may obtain a copy of the specification by application to me at the Rural District Council Offices in Bridgwater, on and after January 1st, 1907, and on payment of One Guinea, to be returned within a fortnight of the receipt of a bonâ-fide Tender.

Sealed Tenders, addressed to me and endorsed "Tender for Cast Iron Pipes," are to be delivered, by post or otherwise, at the Rural District Council Office in Bridgwater, at or before noon of Monday, January 14th, 1907.

The Council do not bind themselves to accept the lowest or any Tender.

(Signed) T. M. REED,
Solicitor and Clerk to the Council.

Bridgwater,
December, 1905. 1947

Elham Union. — Boilers and Pumps for Sale.

TWO CORNISH STEEL BOILERS 5ft. × 30ft.; working pressure 80lb. per square inch; complete, with Hopkinson's fittings, longitudinal seams double riveted; shell 7-16ths, ends 5-8ths; 8 gusset stays, raised manhole; flue seams solid, welded, flanged, Adamson joint; 3 cross tubes in each; in first-class condition.

ONE SET of Warner's Horizontal Three-throw PUMPS: mounted on cast iron frame 3ft. 6in. × 8ft.; solid gun-metal rams, 5in. diameter × 15in. stroke; 2 speeds, counter shaft complete. Only worked a few days.

The above are at the Workhouse, Lyminge (one mile from Lyminge Station, S.E.R.).

Offers for either one or two Boilers or for the Pumps separately to be sent to—

R. LONERGAN,
Clerk to the Guardians,
1961 11, Cheriton-place, Folkestone.

King's Lynn Docks and Railway Company.

LYNN OIL MILL.

The Directors of this Company are prepared to receive TENDERS for the PURCHASE of the following up-to-date MACHINERY:—

1. The Modern SEED-CRUSHING MACHINERY in the above-mentioned Mill, comprising boilers, compound condensing engine, American rolls, stone edge runners, kettles, Anglo-American presses, paring tables, cake racks, iron columns and girders for fixing the machinery accumulators, iron tanks capable of storing about 250 tons oil, and other machinery and appliances for seed crushing, all in good going order.
2. A REFINERY, containing engine for driving pumps, tanks, and complete plant.
3. ENGINE SHAFTING, DYNAMO, and complete plant for electric lighting the whole premises.

The machinery may be inspected on application at this company's offices.

The machinery is in close proximity to rail and water.

Tenders, marked "Oil Mill Machinery," "Refinery," and "Lighting Plant" respectively, for a lump sum for each, to be sent to the undersigned not later than 9th January, 1907.

The Directors would be willing to let the buildings at a very moderate rent to the purchasers of the machinery if they desired to carry on the business of seed crushers.

The Directors do not bind themselves to accept the highest or any Tender.

ARTHUR G. RUSSELL,
General Manager.

Alexandra and Bentinck Docks,
King's Lynn, Norfolk,
20th December, 1906. 1960

Swansea Harbour Trust.—To Engineers and Contractors.

The Swansea Harbour Trustees invite DESIGNS and TENDERS for the CONSTRUCTION and ERECTION of TWO SWING BRIDGES, one over the Entrance Lock to the King's Dock, and the other over the Communication Passage with the Prince of Wales' Dock, together with Hydraulic Machinery for working the same.

On and after 3rd December, 1906, specifications and plans and forms of and instructions for Tender can be obtained on application to the undersigned on payment of Five Guineas, which will be returned as mentioned in the instructions.

TALFOURD STRICK,
Clerk.

Harbour Offices, Swansea,
26th November, 1906. 1701

Swansea Harbour Trust.

CONTRACT FOR HYDRAULIC CRANE.

The Swansea Harbour Trustees invite TENDERS for a Two-ton Portable High Pedestal HYDRAULIC CRANE, with a radius of 40ft.

Further particulars can be obtained on application to the Trustees' Engineer, Mr. A. C. Schenk, Mem. Inst. C.E., at the Harbour Offices, Swansea.

Tenders, sealed and marked "Hydraulic Crane," should be delivered to the undersigned before 10 a.m. on Thursday, 10th January, 1907.

The Trustees do not bind themselves to accept the lowest or any Tender.

TALFOURD STRICK,
Clerk.

Harbour Offices,
7th December, 1906. 1825

The Urban Council of Highbridge.

BRIDGE, Somerset, invite TENDERS for the PURCHASE of the MACHINERY, PLANT, and FITTINGS, at the Disused Waterworks Pumping Station in the Huntspill-road, viz.:—

2 Cornish Type Boilers, built 1885 and 1899 respectively.
2 Vertical Engines by Messrs. Gimson, of Leicester, erected 1886.
Cast Iron Water Tank, bolted, 19ft. 7in. by 18ft. 7in. by 7ft. 8in., on columns and cast iron columns, including wrought iron tie rods, &c.
Filter bed-plates, iron tube, &c.
Sluice Valves, Iron Columns, Flange Pipes, Outlet and Inlet Pipes, with other Plant and Fittings.

Full particulars of which can be obtained from Mr. W. C. Shier, Town Hall, Highbridge, Surveyor to the Council.

The person whose Tender is accepted will be required to sign a contract, a draft of which can be inspected at the office of the Surveyor.

Tenders, marked "Water Works," to be sent to me, the undersigned, on or before the 2nd day of February, 1907.

The Council do not undertake to accept the lowest or any Tender.

B. C. BOARD,
Clerk to the Council.

Highbridge, Somerset,
Dated 20th December, 1906. 1966

Manchester Corporation Water-Works.

HYDRAULIC POWER SUPPLY.
TO ENGINEERS, BOILER MAKERS, AND IRONFOUNDERS.

The Waterworks Committee invite TENDERS for the SUPPLY of the undermentioned IRONWORK, BOILERS, ENGINES, ACCUMULATORS, &c., required in connection with their new Hydraulic Pumping Station, Water-street, Manchester.

CONTRACT No. 3.—Tanks, Girders, Columns, Coal Chutes and Measurers, Overhead Runways, Shafting, &c.
CONTRACT No. 4.—Boilers, Superheaters, Mechanical Stokers, Fuel Economisers, &c.
CONTRACT No. 5.—Steam Pumping Engines, Travelling Crane, Hydraulic Motors, Hydraulic Engines, &c.
CONTRACT No. 6.—Air Lift Plant, consisting of Vertical steam-driven Air Compressor, Air Lift Device, Pipes, &c.
CONTRACT No. 7.—Hydraulic Accumulators, Hydraulic Coal Discharging Apparatus, &c.

Drawings, specifications, and forms of Tender may be obtained on and after Wednesday, the 2nd January, 1907, upon application to the Secretary, Waterworks Offices, Town Hall, Manchester.

A fee of Five Guineas will be charged for each specification, which will be returned on receipt of a bonâ fide Tender.

Further particulars and all other information relating to the specifications and drawings may be obtained from the Engineer and Manager, Hydraulic Power Station, Whitworth-street West, Manchester.

Sealed Tenders, enclosed separately, and endorsed "Hydraulic Power, Tender for ——, Contract No. —," as the case may be, to be forwarded to the Chairman of the Waterworks Committee, at the Town Hall, Manchester, not later than Saturday, the 16th February, 1907.

By order,
WM. HENRY TALBOT,
Town Clerk.

Town Hall, Manchester,
20th December, 1906. 1974

TO CENTRIFUGAL PUMP MAKERS.

The Dublin Port and Docks Board

is prepared to receive TENDERS from Centrifugal Pump Makers for

ELECTRICAL PUMPING MACHINERY FOR THEIR GRAVING DOCK.

The specification, together with a special form of Tender, can be obtained at the office of the Engineer of the Board, John P. Griffith, Esq., M. Inst. C.E., East Wall, Dublin, on payment of One Pound (which will be refunded to firms sending in bonâ fide Tenders).

Tenders, with contractor's supplemental specification and drawings, marked on the outside of the cover "Tender for Pumping Machinery," must be delivered by post, sealed, prepaid, and addressed to the Secretary, Port and Docks Office, Westmoreland-street, Dublin, on or before Tuesday, the 29th day of January, 1907.

The Board does not bind itself to accept the lowest or any Tender.

By order,
N. PROUD,
Secretary.

Dublin Port and Docks Office,
15th December, 1906. 1977

TO CRANE MAKERS.

The Dublin Port and Docks Board

is prepared to receive TENDERS from Crane Makers for—

ELECTRIC WHARF CRANES.

The specification, together with a special form of Tender, can be obtained at the office of the Engineer of the Board, John P. Griffith, Esq., M. Inst. C.E., East Wall, Dublin, on payment of One Pound (which will be refunded to firms sending in bonâ fide Tenders).

Tenders, with contractor's supplemental specification and drawings, marked on the outside of the cover "Tender for Electric Wharf Cranes," must be delivered by post, sealed, prepaid, and addressed to the Secretary, Port and Docks Office, Westmoreland-street, Dublin, on or before Tuesday, the 29th day of January, 1907.

The Board does not bind itself to accept the lowest or any Tender.

By order,
N. PROUD,
Secretary.

Dublin Port and Docks Office,
15th December, 1906. 1973

The South Indian Railway Company,

LIMITED, is prepared to receive TENDERS for the SUPPLY of:—

(1) GENERAL STORES, comprising Hardware, Iron, Steel, Oils and Colours, Leather and Rubber Goods, Electric Stores, and Sundries.
(2) LOCOMOTIVE STORES, comprising Copper and Steel Plates, Tyres, Springs, Tubes, and Trolleys.
(3) STATIONERY, comprising Tickets, Books, Paper, Envelopes, and Sundries.

Specifications and forms of Tender may be obtained at the Company's Offices on and after Monday, the 31st December, 1906.

Tenders, addressed to the Company, marked "Tender for Stores," must be left with the undersigned not later than 12 o'clock noon of Tuesday, the 22nd January, 1907.

A charge, which will not be returned, will be made of 20s. for each copy of Specification No. 1, and of 10s. for each copy of Nos. 2 and 3.

Copies of the drawings may be obtained at the office of Sir George B. Bruce, 3, Victoria street, Westminster, on payment of 5s. per sheet.

By order,
HENRY W. NOTMAN,
Managing Director.

Company's Offices:
55, Gracechurch-street, London, E.C.,
28th December, 1906. 1932

Urban District Council of Caterham.

CATERHAM MAIN DRAINAGE.
CONTRACT No. 1.
TO CONTRACTORS.

The Urban District Council of Caterham are prepared to receive TENDERS for the CONSTRUCTION of the following WORKS:—

About 10½ Miles of Stoneware and Iron Sewers, ranging from 8in. to 18in. in diameter, with the necessary Manholes, Flushing Tanks, and other appurtenances.
Purification Works, consisting of Settling Tanks, Contact Beds, Streaming Beds, Sand Filters, and other works.

The whole of the said works to be carried out in accordance with the plans and specification prepared by Messrs. John Taylor, Sons, and Santo Crimp, Civil Engineers.

Intending contractors may obtain copies of the specification and bill of quantities, with form of Tender, and inspect the drawings, at the offices of the aforesaid firm of Engineers, Caxton House, Westminster, upon payment of £5 (cheque only), which will be returned upon the receipt of a bonâ fide Tender.

Tenders, endorsed "Caterham Drainage, Contract No. 1," must be delivered in a sealed package addressed to the undersigned at the Urban District Council Offices, Caterham Valley, before 4 p.m. on Wednesday, the 23rd day of January, 1907.

The Council do not bind themselves to accept the lowest or any Tender.

By order,
F. B. WINTER,
P608 Clerk.

West Ham Union.—The Guardians

REQUIRE the SERVICES, temporarily, of a WORKING ENGINEER (non-resident) at the Infirmary, Whipps Cross-road, Leytonstone, N.E., at a salary of £3 per week.

Candidates must be fully competent to take charge of the electric lighting installation, the lifts, and the general engineering work of the establishment.

Applications, on forms which can be obtained at my office, must be sent to me by Wednesday, the 2nd January, 1907.

Canvassing the Guardians is strictly prohibited.

By order of the Board,
FRED. E. HILLEARY,
Clerk.

Clerk's Office, Union Workhouse,
Leytonstone, N.E., 22nd December, 1906. 1989

Parish of Saint Pancras.

GUARDIANS OF THE POOR.
TO HYDRAULIC ENGINEERS.
FIRE MAIN.

The Guardians of this Parish invite TENDERS for SUPPLYING, DELIVERING, and LAYING about 999 yards length of CAST IRON SOCKET PIPES, with all Specials, Valves, and Hydrants, viz.:—About 333 yards of 6in., about 333 yards of 5in., about 333 yards of 4in. respectively, at St. Pancras Schools, at Leaveden, near King's Langley, Herts; as per plans, specifications, and conditions, which can be inspected at the Town Hall, or at the Schools.

Any further particulars may be obtained at either of the above places on application.

The Guardians do not bind themselves to accept the lowest or any Tender.

ALFRED A. MILLWARD,
Clerk to the Guardians.

Town Hall, Pancras-road, N.W.,
21st December, 1906. 1993

Devon County Asylum.—

WANTED, a SECOND RESIDENT ENGINEER.

He must be a thoroughly well-trained Mechanic accustomed to Take Charge of Electric and Steam-power Appliances, Telephones, Electric Lighting, &c.

He must also be a good Engineering Fitter.

Wages thirty shillings (30s.) per week, with cottage free.

Applicants to state age, also whether married or single.

Testimonials and applications to be delivered to me not later than the 29th instant.

E. H. HARBOTTLE, F.R.I.B.A.,
Architect of the Devon County Asylum.

County Chambers, Exeter,
13th December, 1906. 1917

Wanted, Gas Engineer for

Brazil, competent in Theory and Practice, to Take Charge of Crossley Engine and Plant.—Apply, by letter, with testimonials, to W. R. BLAND and CO., 14, St. Mary Axe, London. 1984

Permanent Appointments.—Good

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of FORMIC ACID according to approved treatment? Eventually SITUATION.—Apply to F. B. 546, Hanenstein and Vogler, A.G., Magdeburg (Germany). 1963

Wanted Immediately, Draughtsman,

used to intricate small Electrical Apparatus.—Address, stating age, references, and salary, to P606, Engineer Office, 33, Norfolk-street, Strand, W.C. P606

Draughtsman, Experienced in

Hydraulic Dock Machinery, including Cranes, Hoists, &c., for large works on Tyneside.—Address, stating age, experience, when at liberty, and salary required, to P598, Engineer Office, 33, Norfolk-street, Strand, W.C. 1969

Junior Draughtsman Wanted,

for Details Gas, Oil Engines, Gas Plants, and Automobiles. Give full particulars and experience. Also PREMIUM PUPIL.—Address, P606, Engineer Office, 33, Norfolk-street, Strand, W.C. P606

Smart Junior Draughtsman

WANTED near London for Machine Tool Work. Must be thoroughly reliable, and have had shop experience. None but first-class men need apply.—Address, 1955, Engineer Office, 33, Norfolk-street, Strand, W.C. 1955

High-speed and Horizontal Gas

ENGINES AND SUCTION GAS PLANTS.—Firm of Manufacturers are open to APPOINT energetic AGENTS for several districts where not represented.—Address, 1925, Engineer Office, 33, Norfolk-street, Strand, W.C. 1925

Motor Omnibuses and Petrol

LORRIES.—WANTED, in the following districts, viz.: Glasgow, Cardiff, Leeds, and the Potteries, a smart and energetic GENTLEMAN to TAKE UP the REPRESENTATION of an ALL-BRITISH MOTOR OMNIBUS and HEAVY PETROL LORRY. Must be well in touch with municipal authorities, large trading firms, railway companies, and other likely purchasers. Engineer preferred. Highest references required.—Apply, RYKNIELD MOTOR CO., Ltd., Burton-on-Trent. 1930

Agent Wanted in London,

preferably Engineer, for the Sale, on commission, of Machine Tools used by Ship and Bridge Builders, Boilermakers, &c., produced by a first-class firm of Scottish Engineers. Must have an established connection at home and abroad.—Address, 1975, Engineer Office, 33, Norfolk-street, Strand, W.C. 1975

Wanted, for Engineer's Office in

Manchester, a smart, well-educated CLERK, age about 21; good quick writer and calculator; shorthand and typewriting essential. Permanency and good prospects for suitable applicant. State full particulars.—Address, L., Box 798, Smith's Advertising Agency, 100, Fleet-street, E.C. 1924

Wanted, for 25th January, First-

CLASS FITTER and ERECTOR to erect Water-tube Boiler, High-speed Engine, and Dynamo and Condensing Plant in Argentine Republic. Experience with high-speed engines essential. Previous experience abroad and knowledge of Spanish desirable. Engagement for six months. Salary £25 per calendar month. Free second-class passage out and home. Full pay during voyage.—Application by letter only to Messrs. PREECE and CARDEW, 8, Queen Anne's-gate, Westminster, S.W., to be sent in not later than January 3rd, giving age and brief particulars of experience, with names of two personal references. 1983

Wanted, One or Two Good

VICE and LATHE HANDS accustomed to high-class Electrical Fittings. State age, experience, and wages required.—THE SWITCHGEAR CO., Ltd., 49, Newhall-street, Birmingham. P611

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Boats and Cars; also PATTERNMAKER. None but first class men need apply.—Apply, DIXON BROS. and HUTCHINSON, Woolston, Southampton.

Milling Machine Hands, Grinders

and FITTERS, also TURNERS for Capstan Lathes, WANTED for Works in the North of Scotland. Permanent employment for competent men. Address, 1994, Engineer Office, 33, Norfolk-street, Strand, W.C. 1994

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experience and part technical education, DESIRES DRAWING-OFFICE TRAINING; knowledge of drawing.—Address, P603, Engineer Office, 33, Norfolk-street, Strand, W.C. P603

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Engineer (22), 7½ Years' experience in brewery, chemical, motor, and some tool and jig work, through all shops and D.O., REQUIRES SITUATION. Good ref.—Address, P609, Engineer Office, 33, Norfolk-street, Strand, W.C. P609

Engineer (23) Desires Change; thoroughly practical, shops and drawing-office, pumping machinery and general engineering experience; absolutely reliable; moderate salary.—Address, P616, Engineer Office, 33, Norfolk-street, Strand, W.C. P616

Frenchman (23½), Knowledge of English and Engineering Experience, REQUIRES SITUATION as DRAUGHTSMAN or CORRESPONDENT; excellent references.—FEYEUX, 35, St. James's-road, Watford. P617

Mechanical Engineer, A.M.I. Mech. E. (33 years), SEEKS RESPONSIBLE POSITION at home or abroad. Has 15 years' shop and outside experience with one of the best engineering firms in London and 6 years resident engineer in Brazil; quite acclimatised to the tropics; used to looking after large staff of men. A good practical training and knowledge of electric lighting, with first-class testimonials. At present in Brazil.—Address, P610, Engineer Office, 33, Norfolk-street, Strand, W.C. P610

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Wanted, Pair of 12in. Hauling ENGINES, with one or two loose drums; self-contained.—H. SAMPSON and SONS, Malago Vale, Bedminster, Bristol. 1976

Wanted, Set Bending Rolls, to take plates 17ft. or upwards by ¾in. New or good modern second-hand, steam or belt driven; former preferred. Housings arranged to take off endways a plate rolled into tube form.—Address, 1987, Engineer Office, 33, Norfolk-street, Strand, W.C. 1987

Wanted, Ten 10-Ton Railway COVERED GOODS VANS, in good condition, and built to railway companies' new regulations.—Address, 1986, Engineer Office, 33, Norfolk-street, Strand, W.C. 1986

Wanted, the Following R. S. JOISTS (Second-hand will do):—100, 7ft. – 6in. × 3in., and 60, 7ft. – 6in. × 4in. Please state nearest lengths and sections you have to these, your price at per ton delivered West End London, and where they can be inspected.—Address, 1985, Engineer Office, 33, Norfolk-street, Strand, W.C. 1985

Air Compressor (Steam Driven), second-hand, WANTED, capable of compressing from 4 to 5000 cubic feet of air per minute to a pressure of 140 lb. per square inch; must be in good condition; required to run continuously.—Address, 1967, Engineer Office, 33, Norfolk-street, Strand, W.C. 1967

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Two 30 by 8ft. 3in.;	will insure	150 lb.
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For Sale, a Modern 19-Ton HYDRAULIC COAL HOIST, complete with steel framing, cradle, tipping frame, shoot, and operating machinery; height of frame 43ft., stroke of rams 26ft.—For particulars and drawings apply, J. J. LEE, Machinery Merchant, Crumpsall, Manchester. 1797

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For Sale, Nasmyth Wilson's 3-cwt. STEAM HAMMER, PUNCHING and SHEARING MACHINE, 30in. gap; 4ft. 6in. and 6ft. BENDING ROLLS; Flue Flange DRILLING MACHINE; must be removed.—RUSHWORTH, Sowerby Bridge. 1956

For Sale, 2 Marine Loco. Type BOILERS, about 400 H.P. each, insured for 130 lb. pressure, all fittings as now fixed, cheap, for immediate delivery.—WILLIAMS and SONS, South Bermondsey Station, London, S.E. 1887

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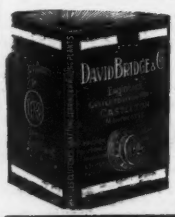

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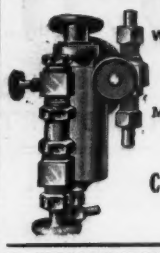

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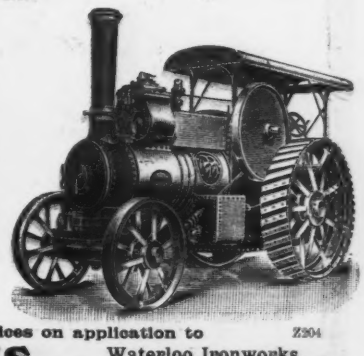

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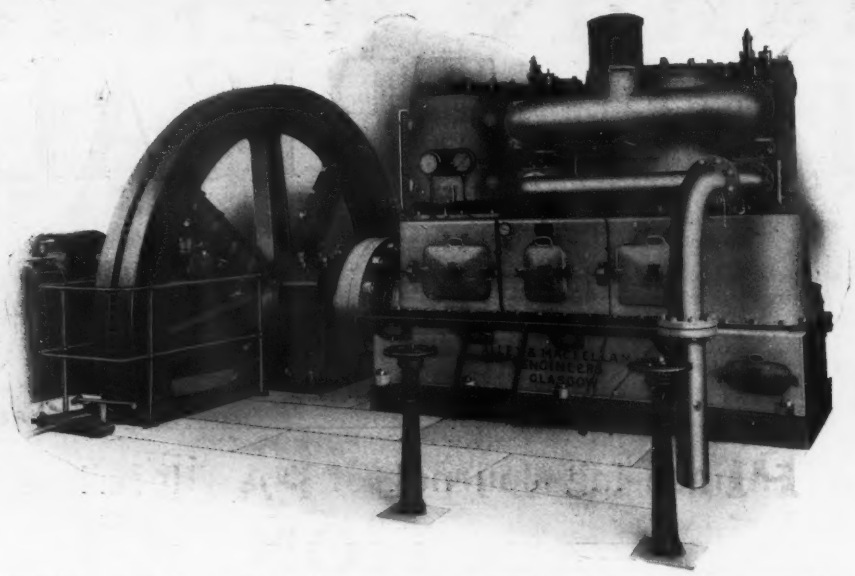

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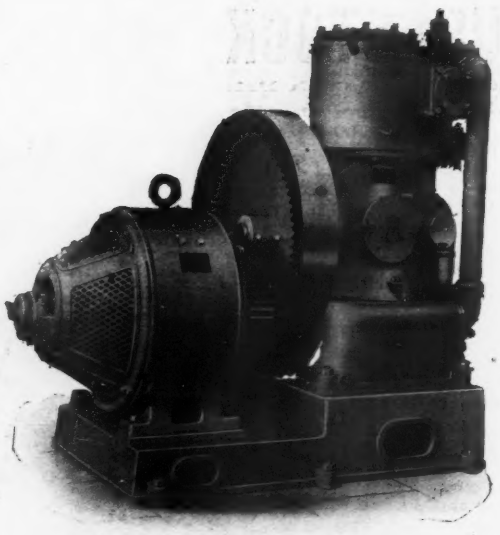

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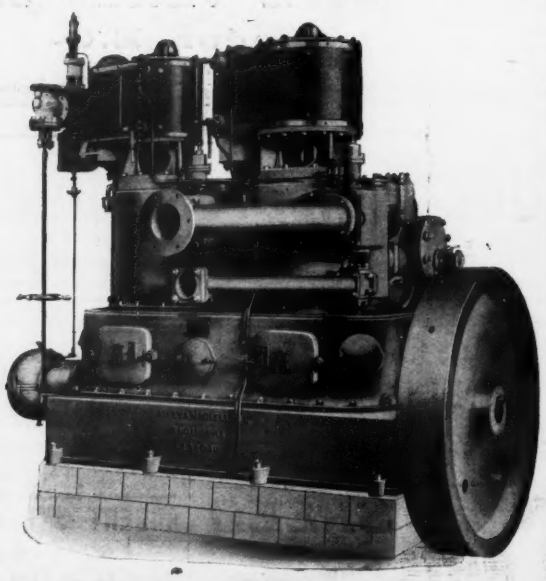

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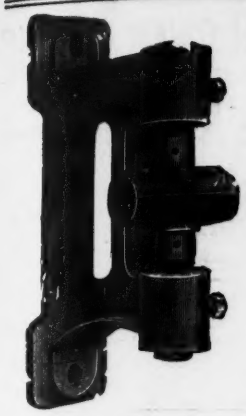

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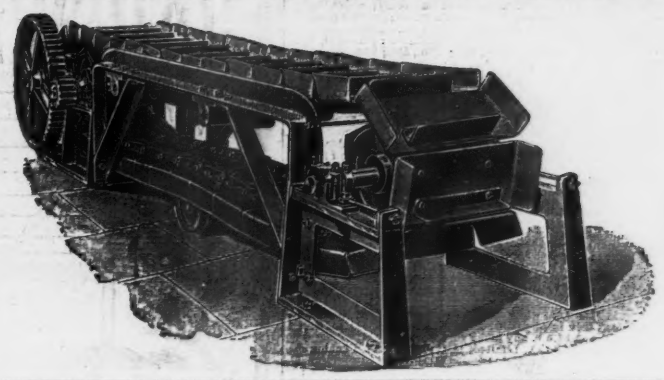

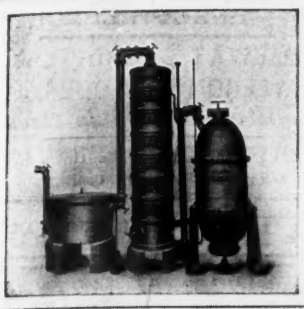

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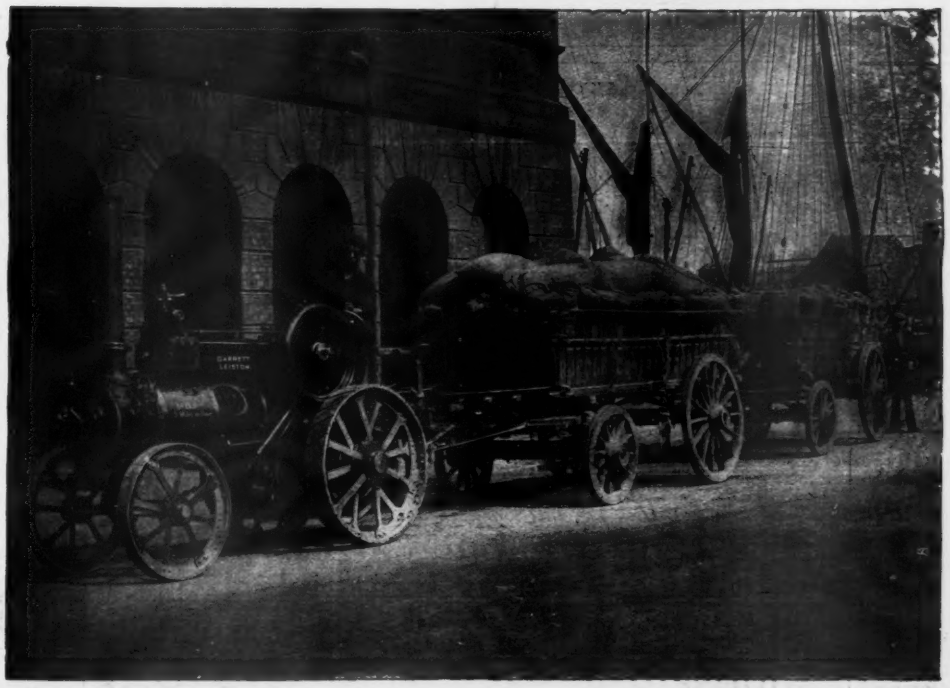

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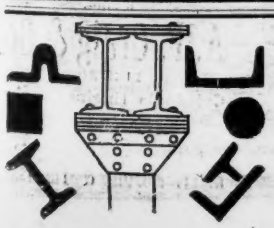

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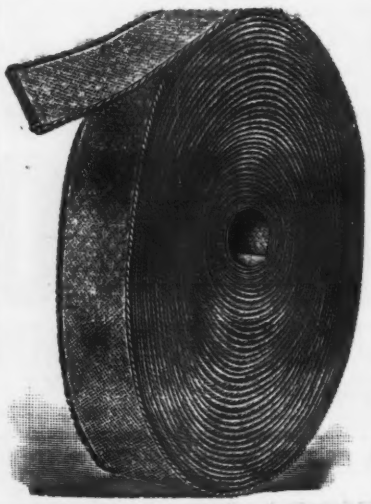

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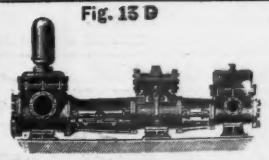

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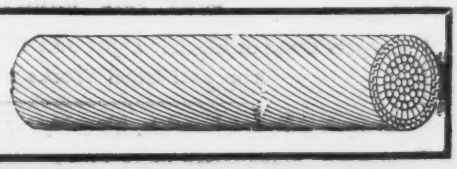

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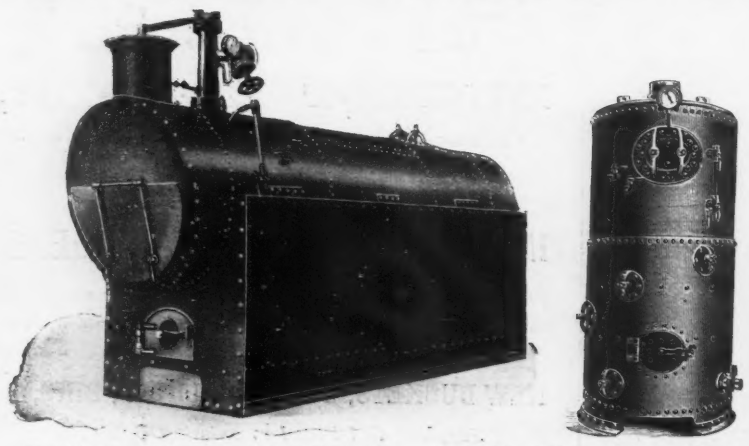

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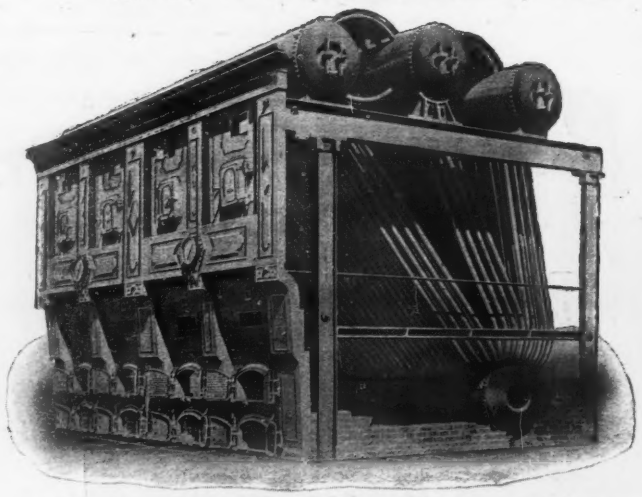

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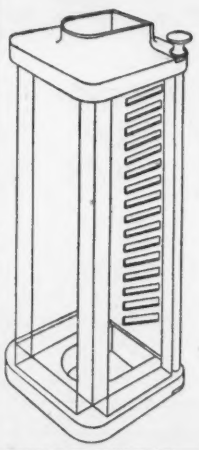

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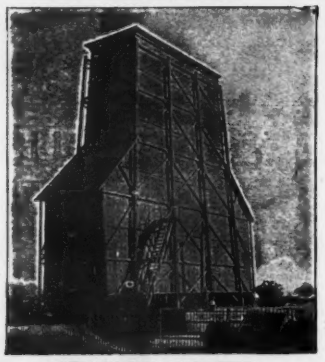

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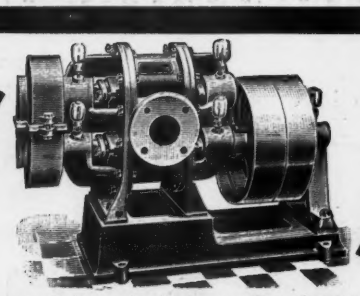

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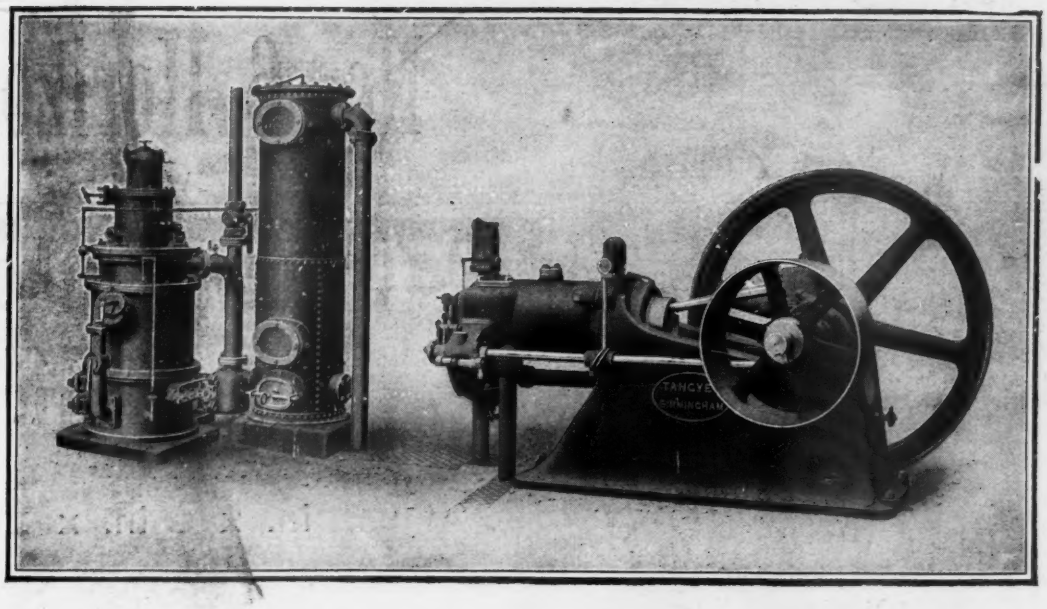

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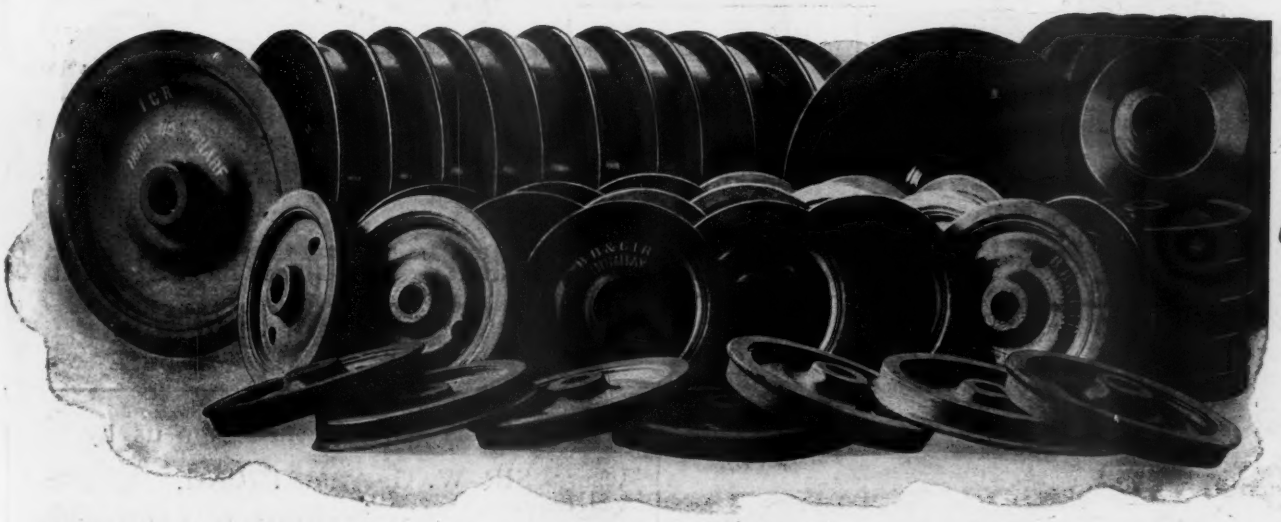

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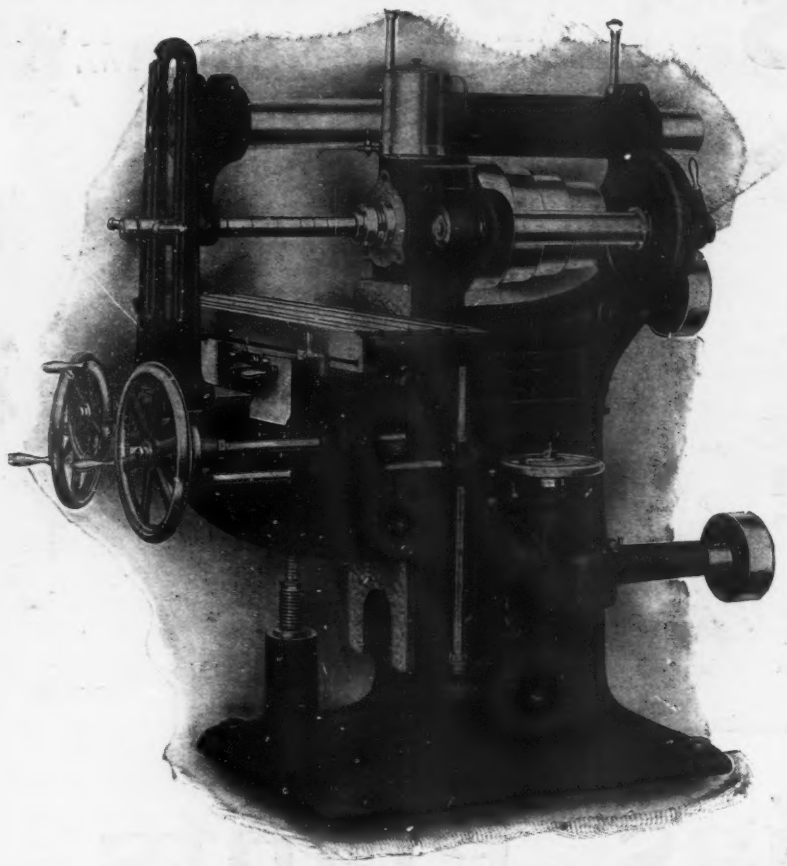

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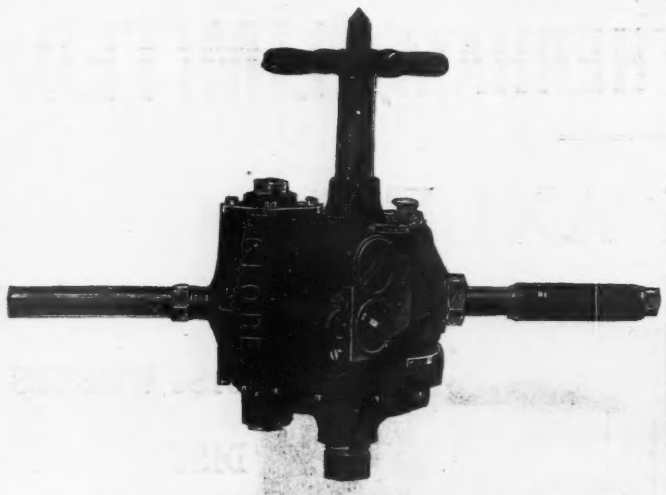

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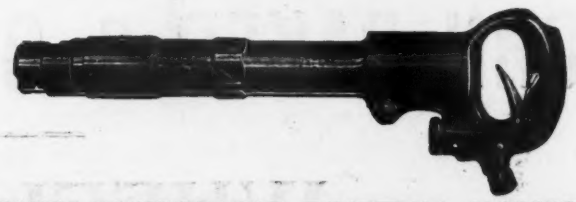

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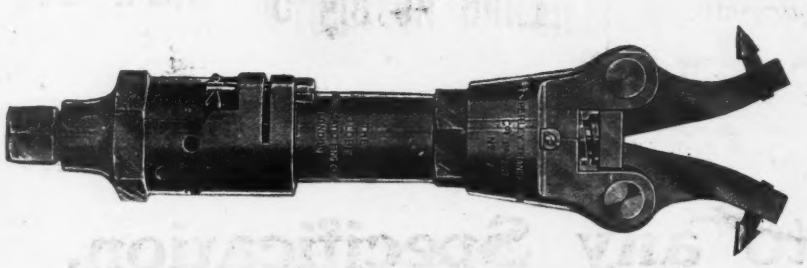

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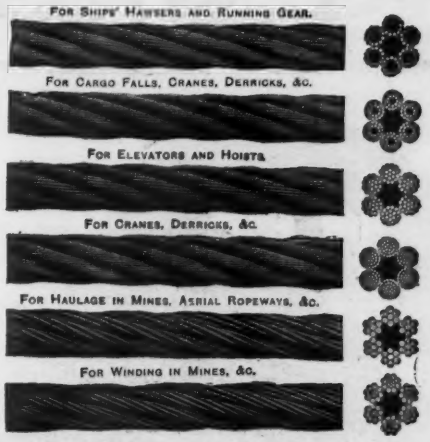
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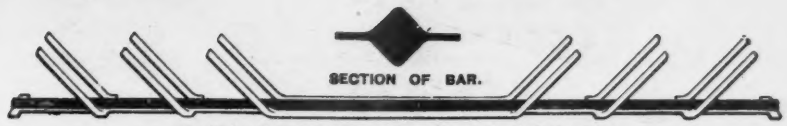

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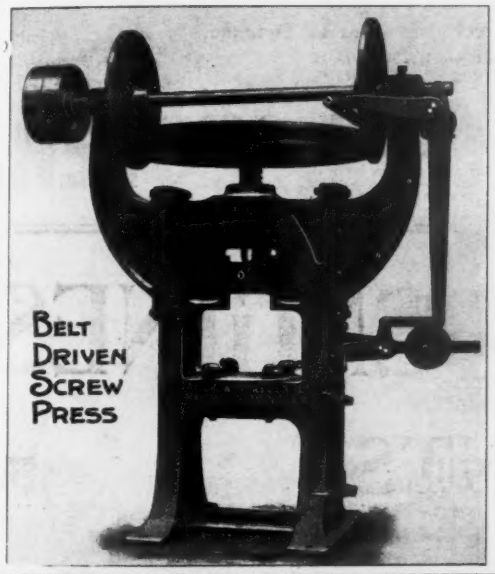

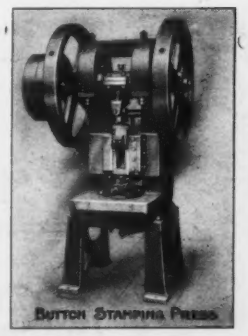

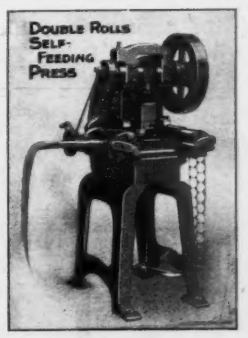

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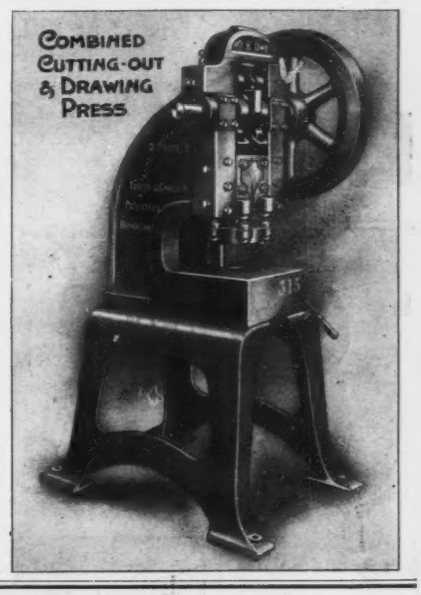

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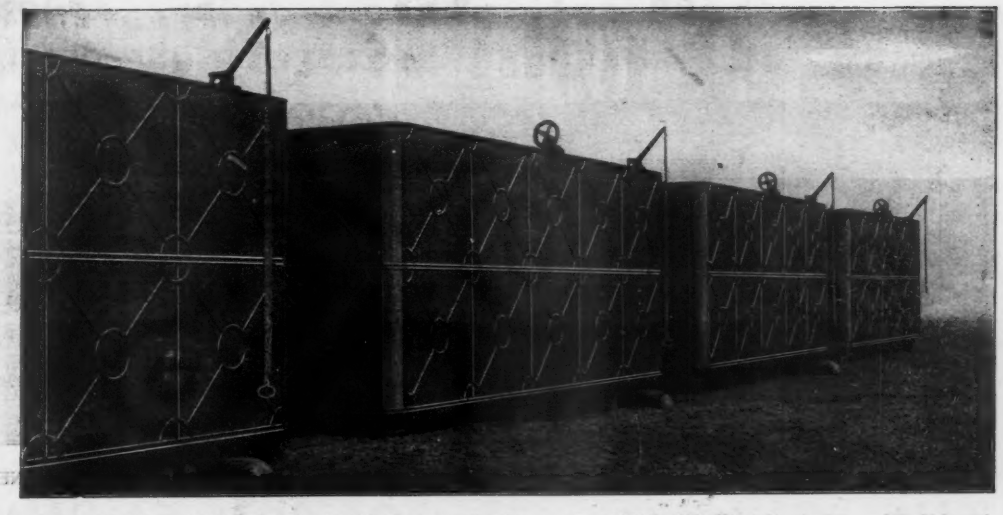

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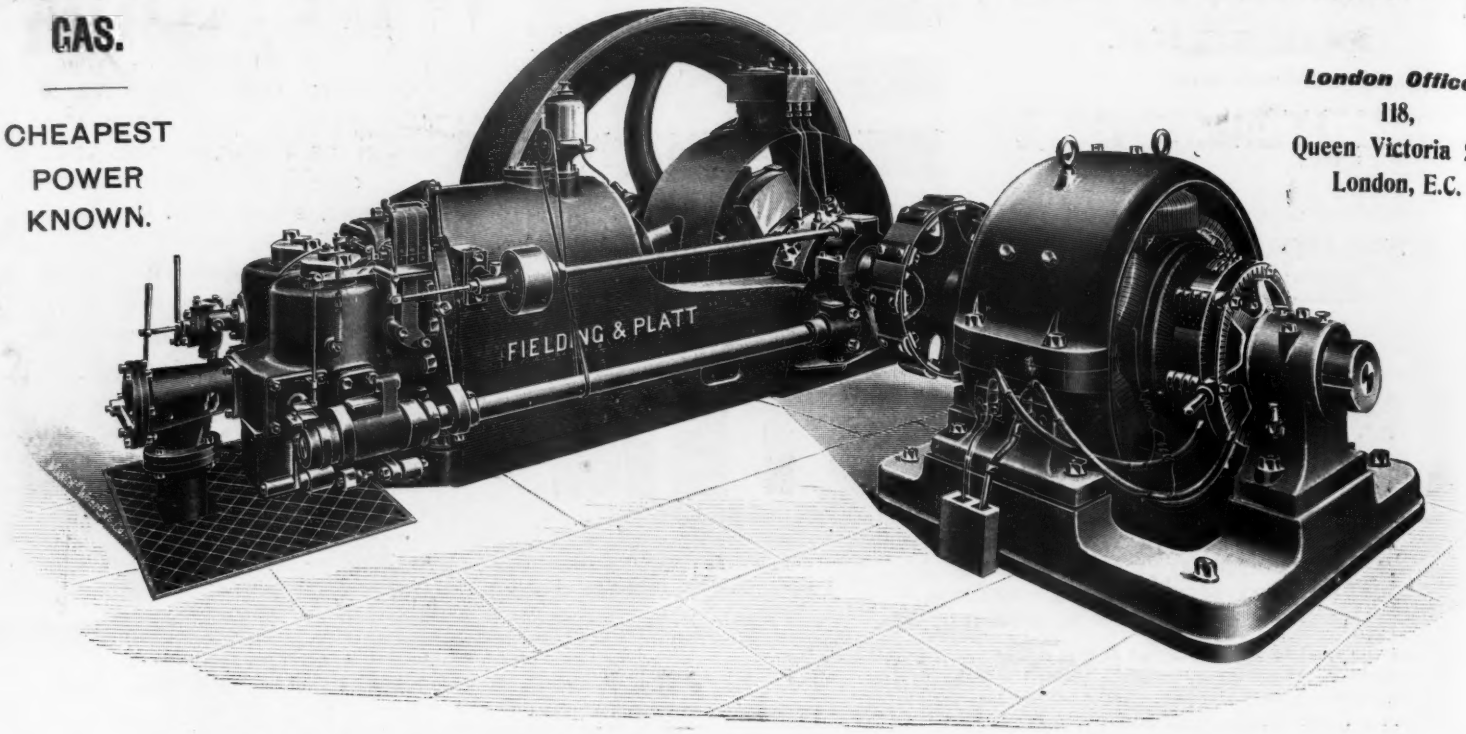

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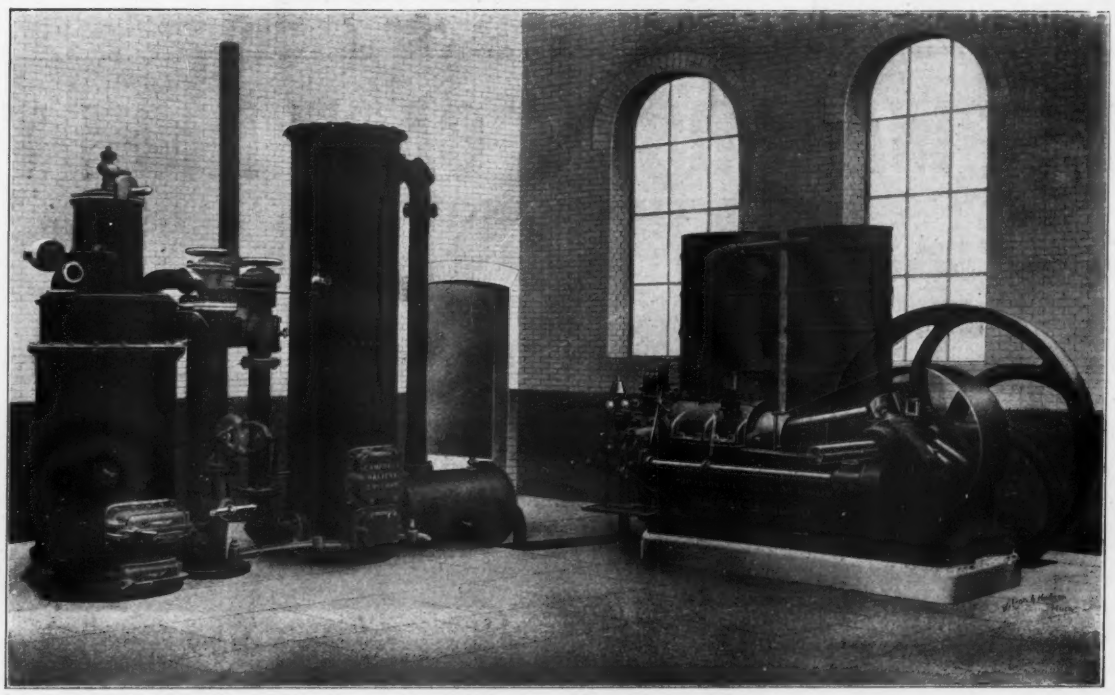

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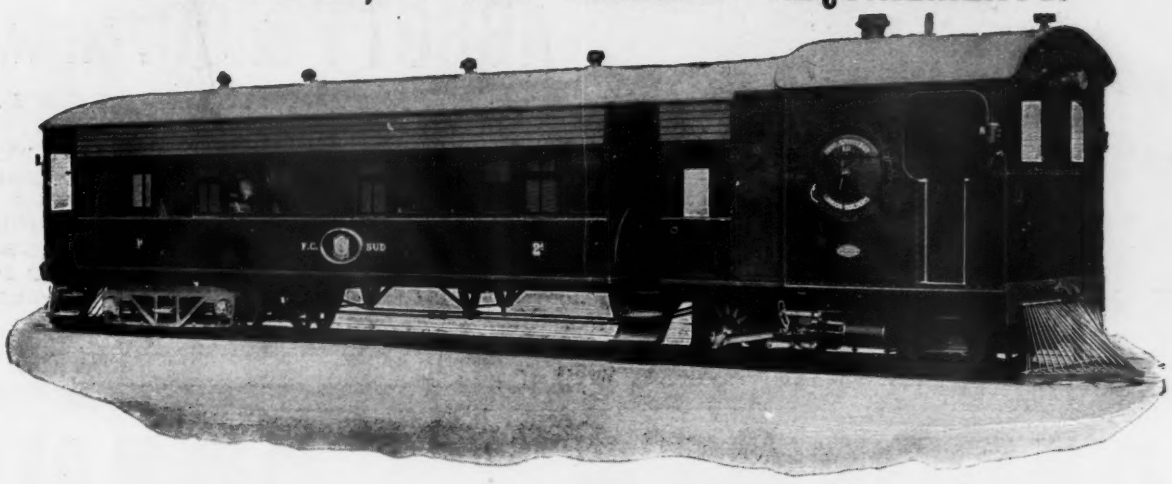

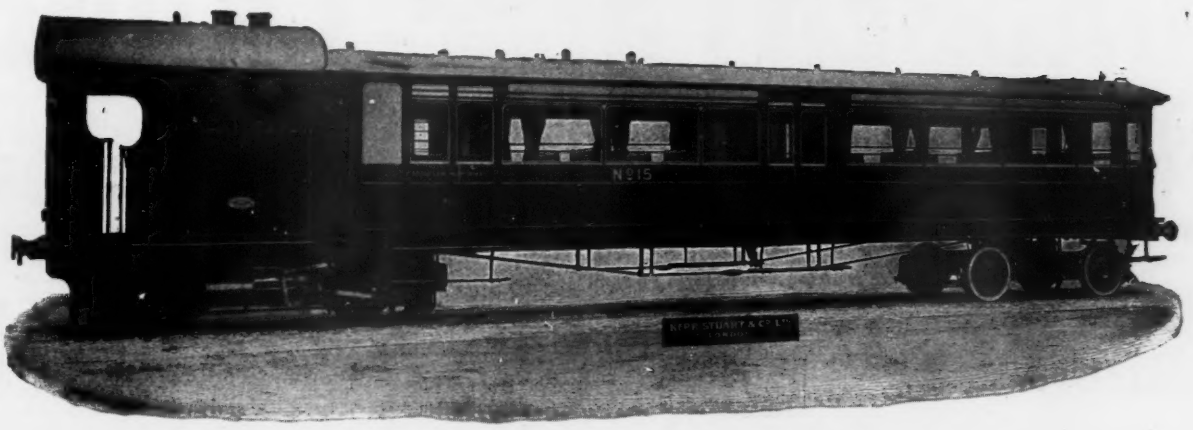

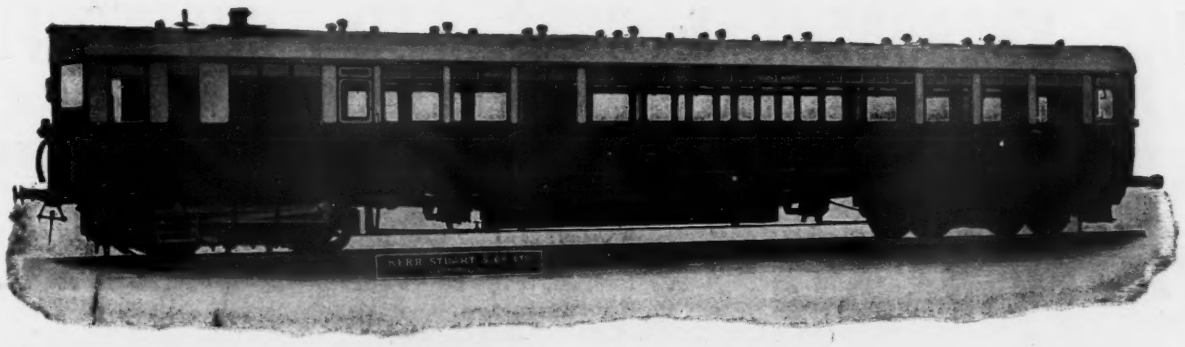

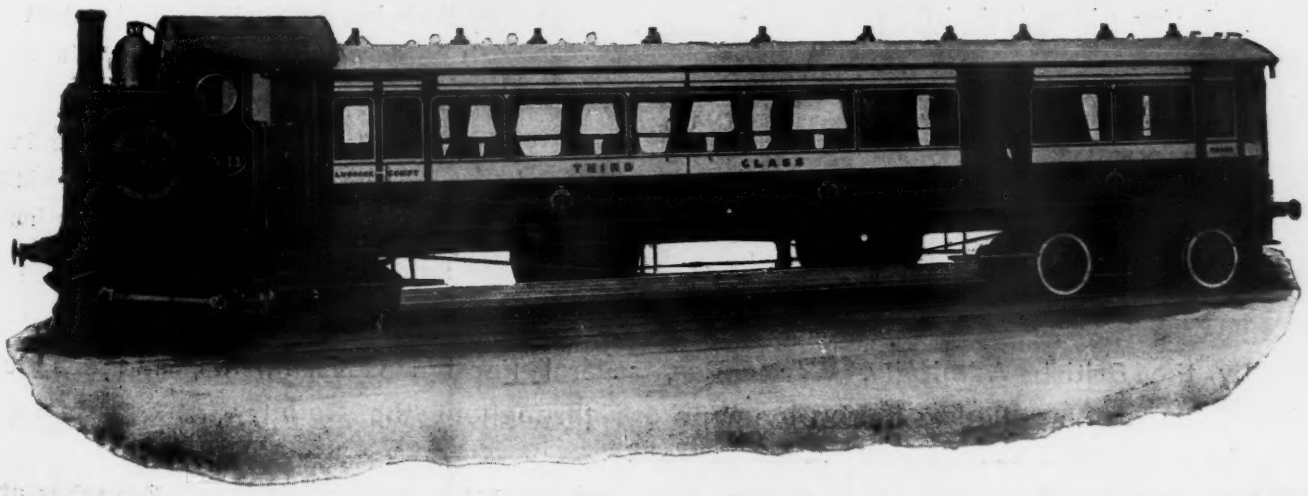

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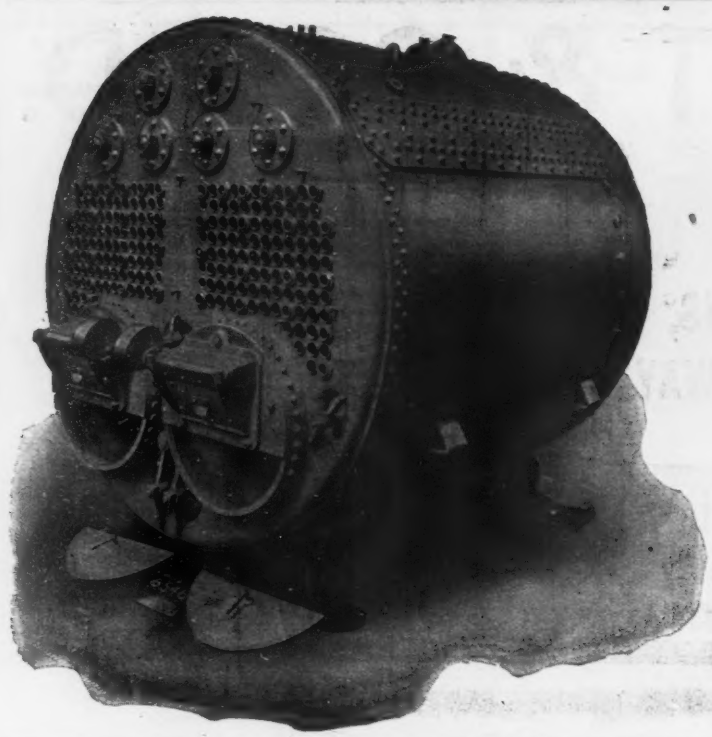

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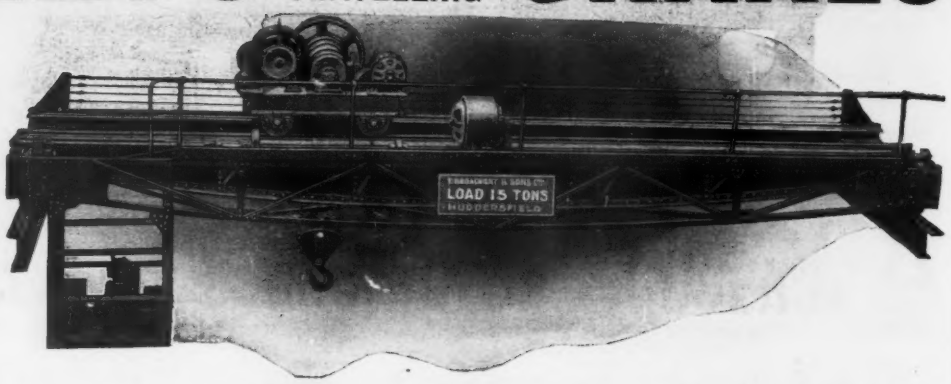

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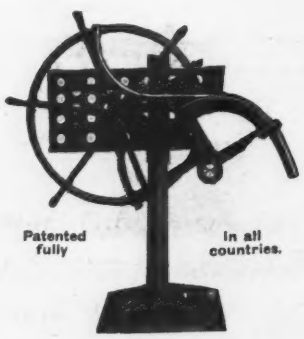

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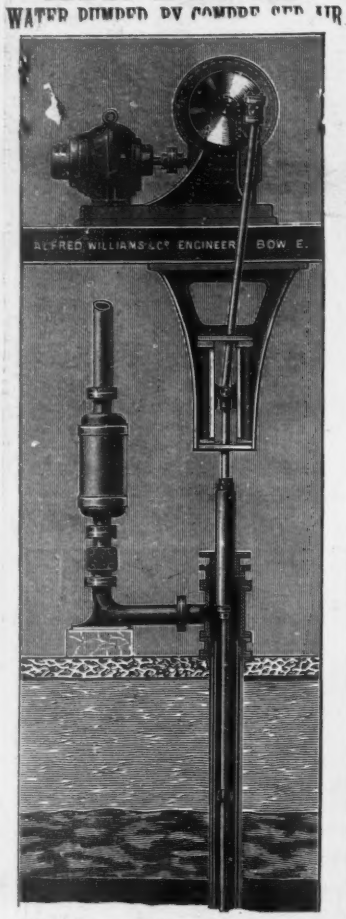

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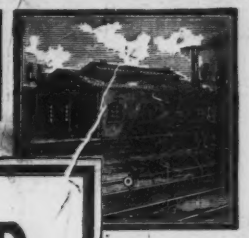

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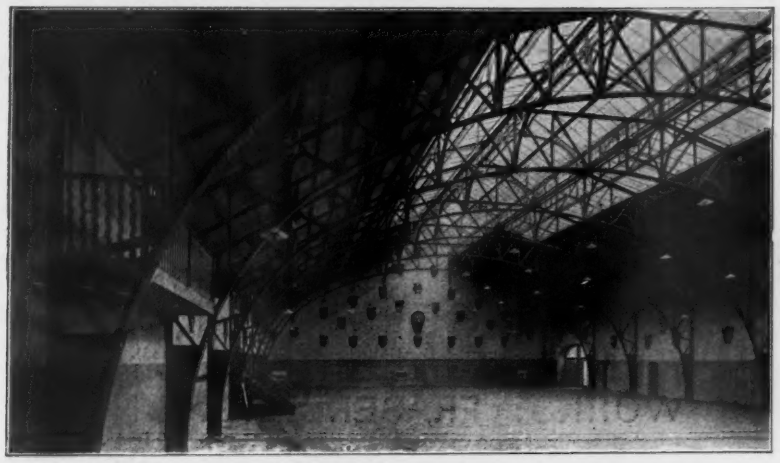

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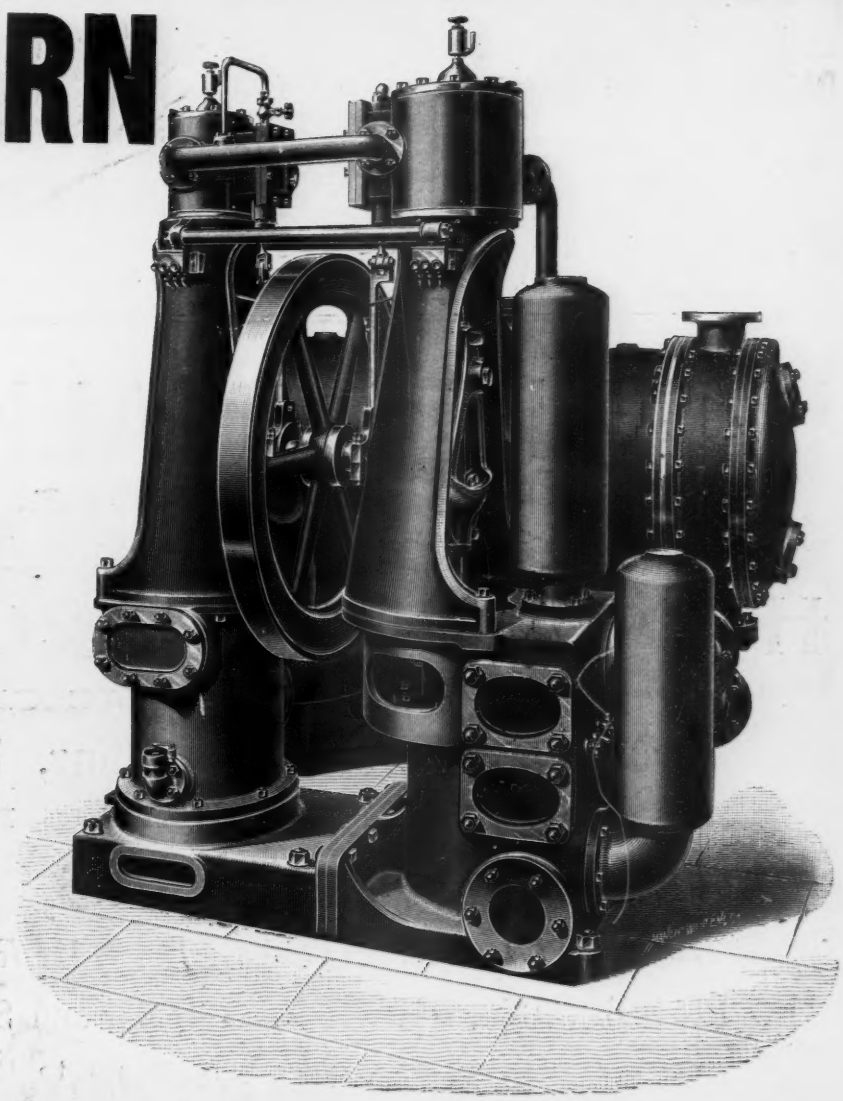

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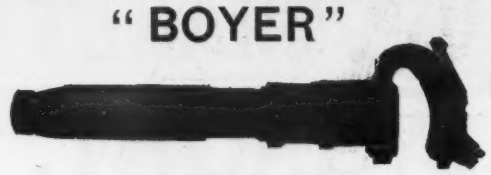

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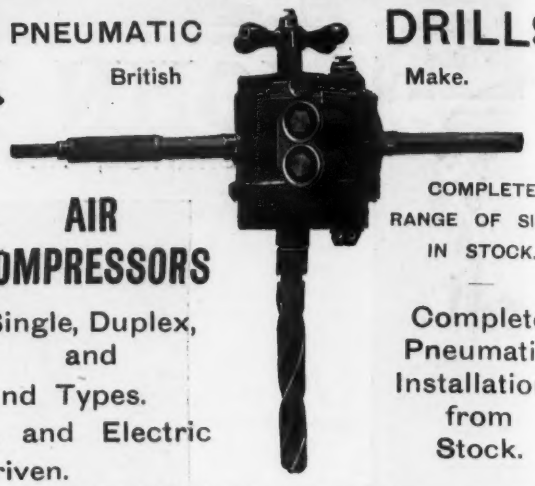

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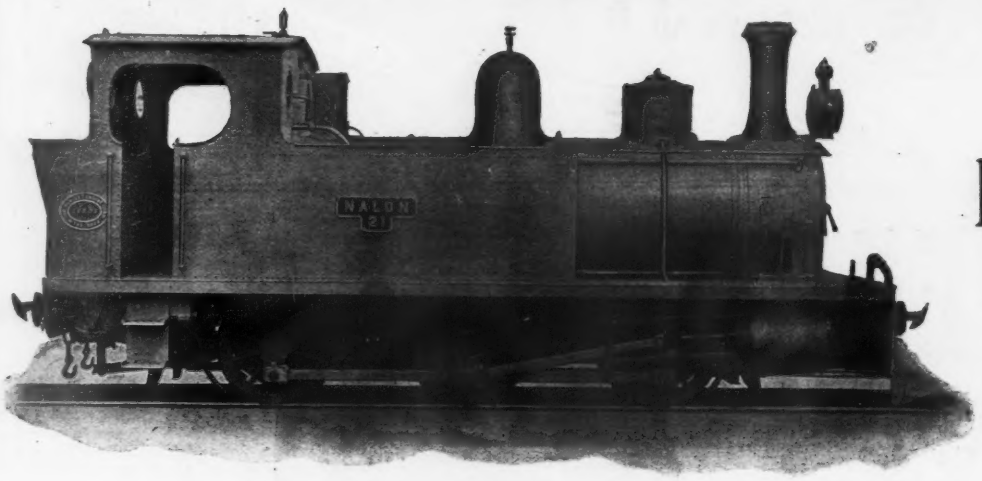

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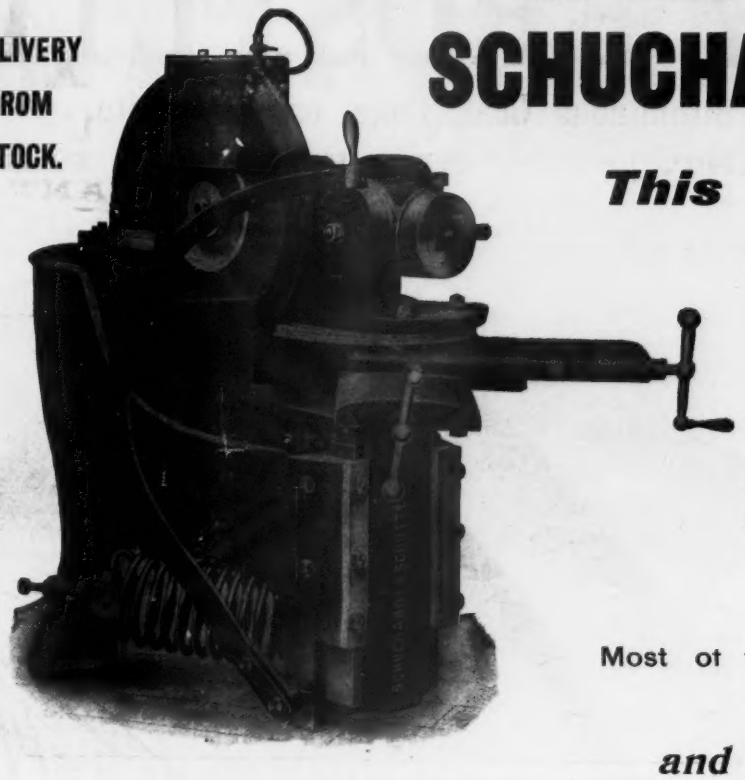

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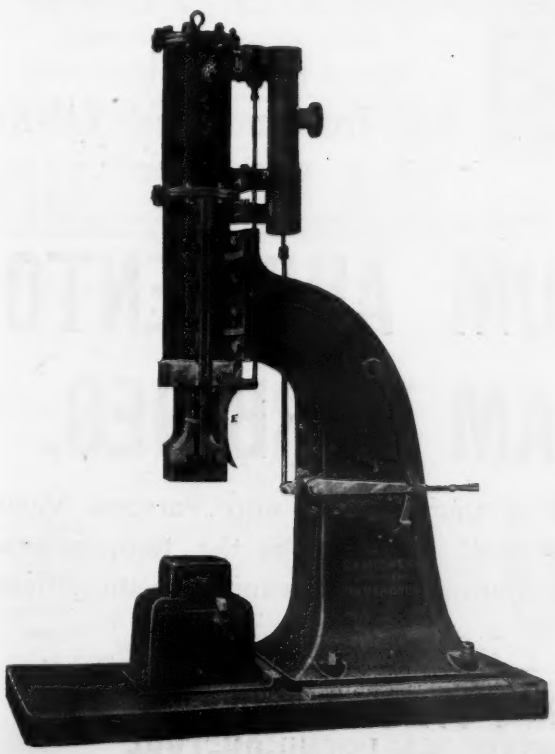

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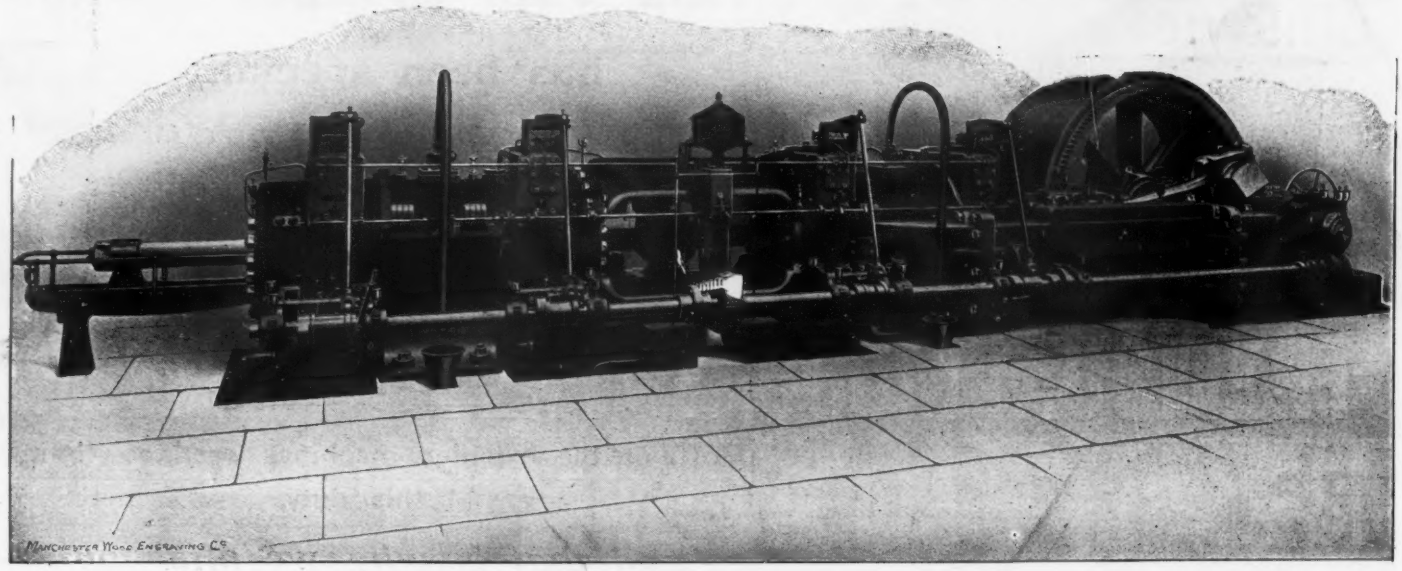

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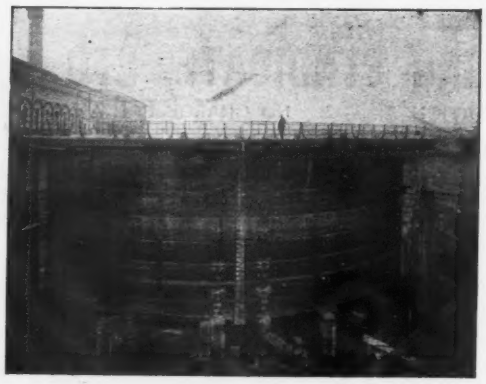

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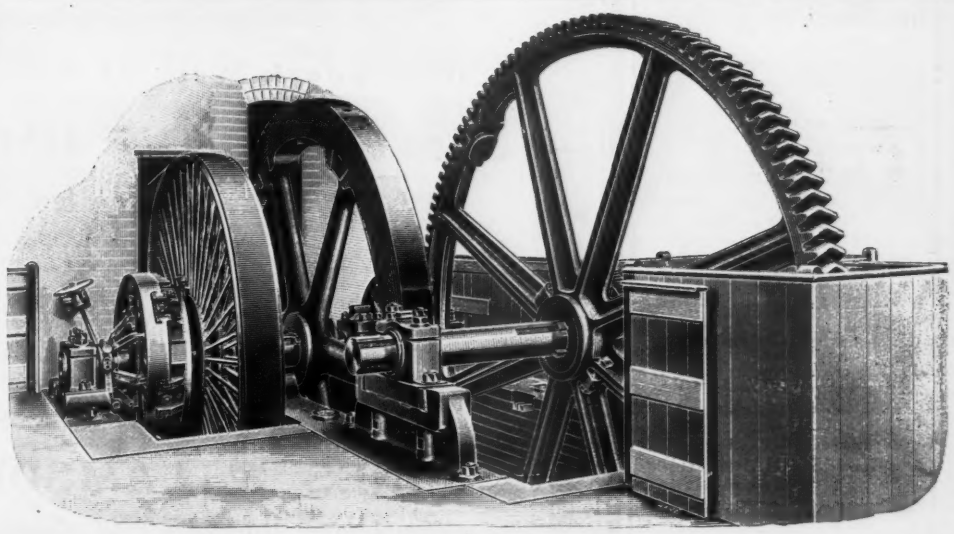

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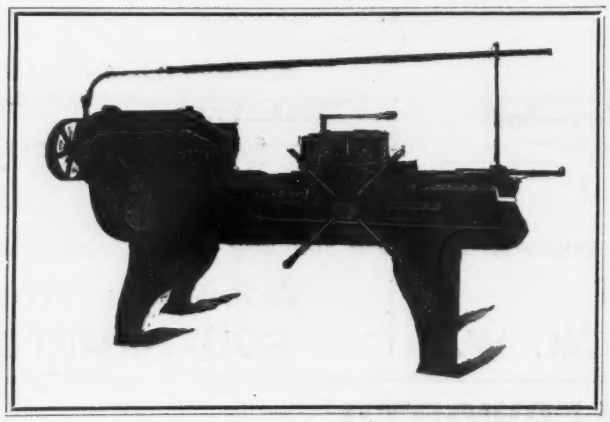

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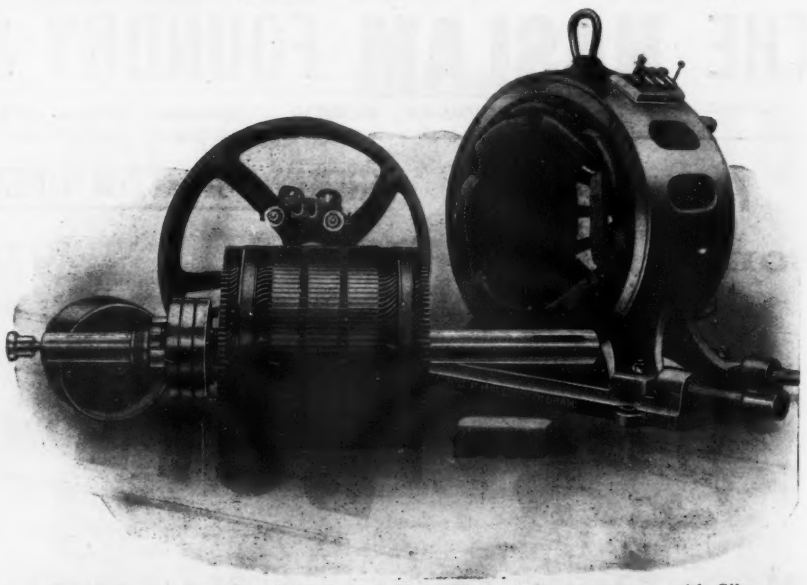

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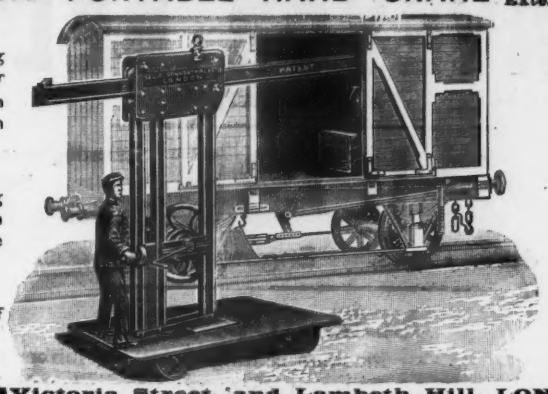

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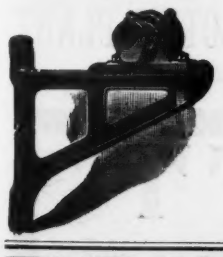

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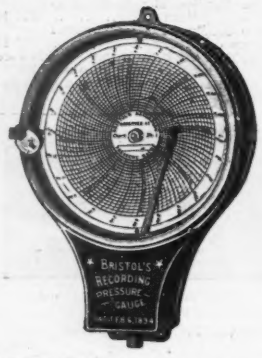

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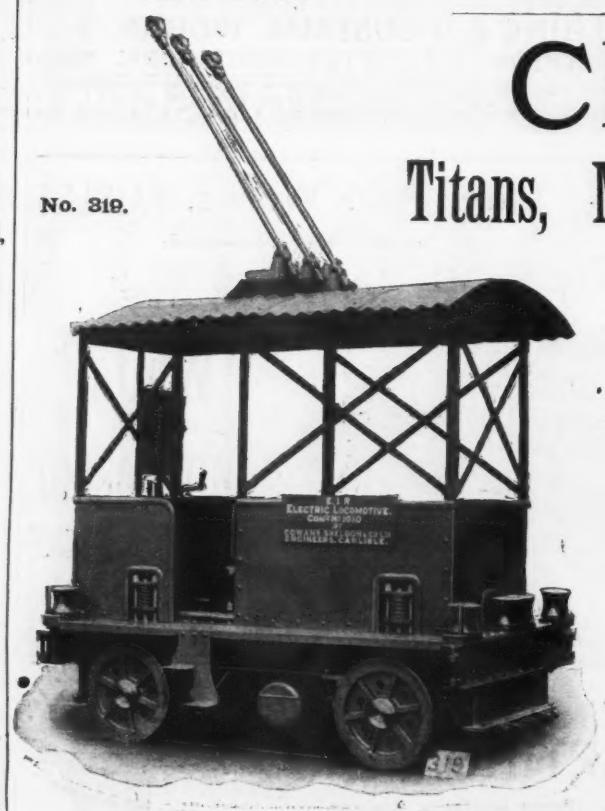

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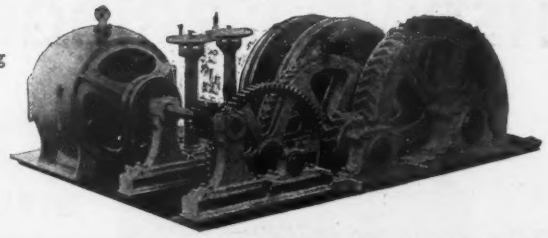

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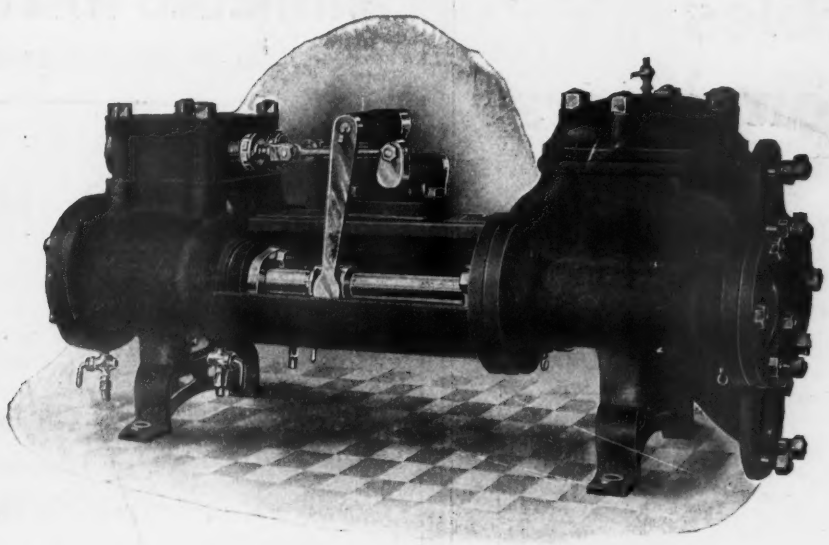

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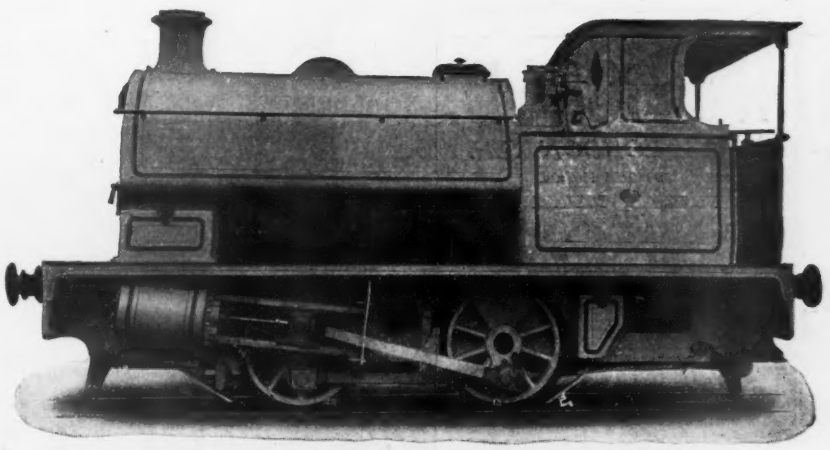

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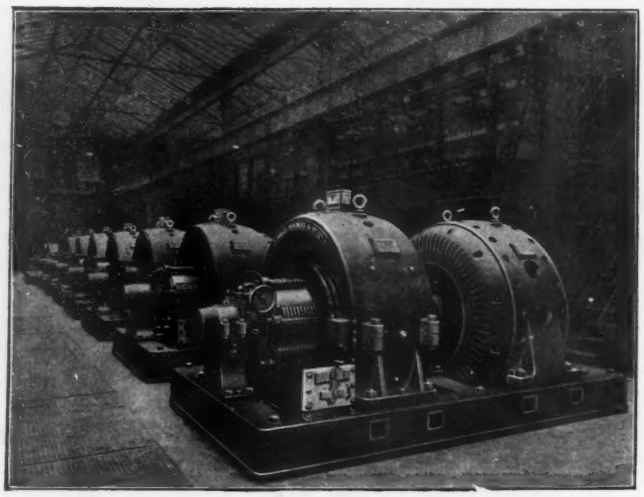

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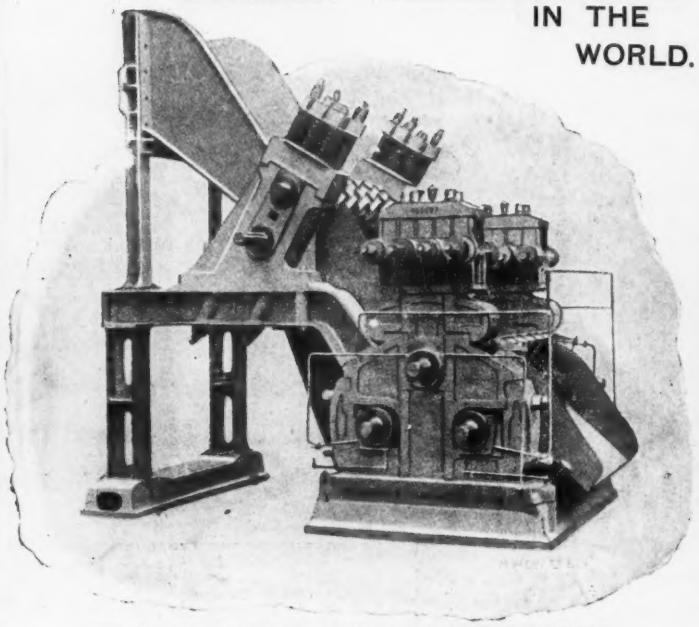

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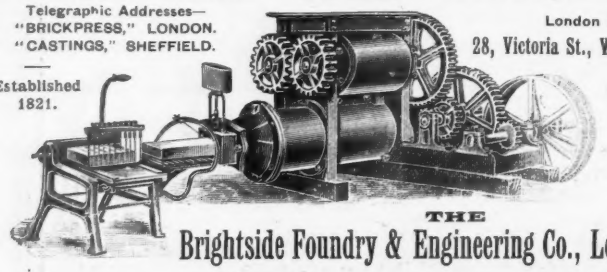

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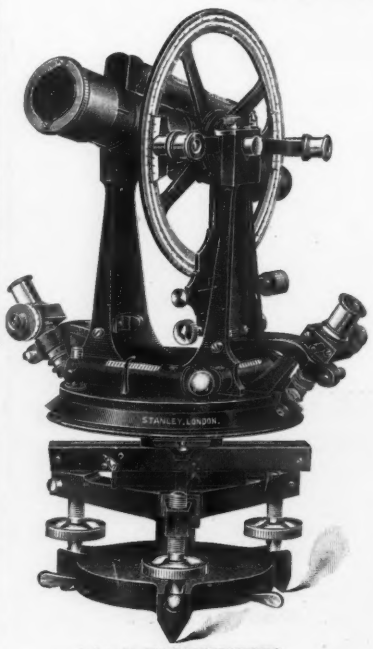

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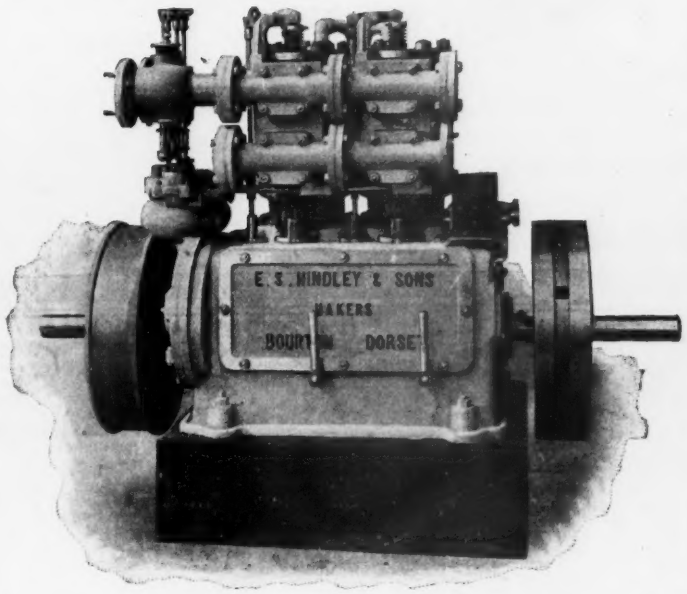

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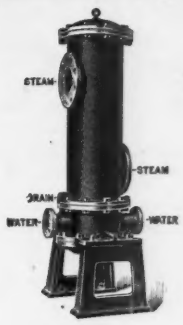

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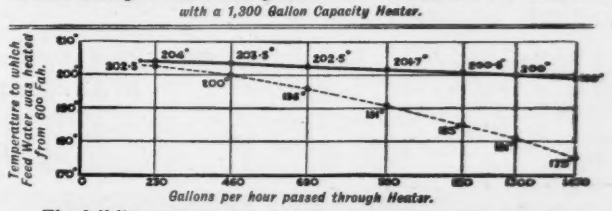

The full line represents the higher temperatures obtained when reducing the quantity of feed water and maintaining a constant flow of Exhaust Steam (at atmospheric pressure) half the weight of the listed water capacity of the heater. **The dotted line gives** the temperatures obtained with only 2,300 lbs. of steam per hour, and shows that a temperature of 175° Fah. is reached with water 6·4 times the weight of the steam used.

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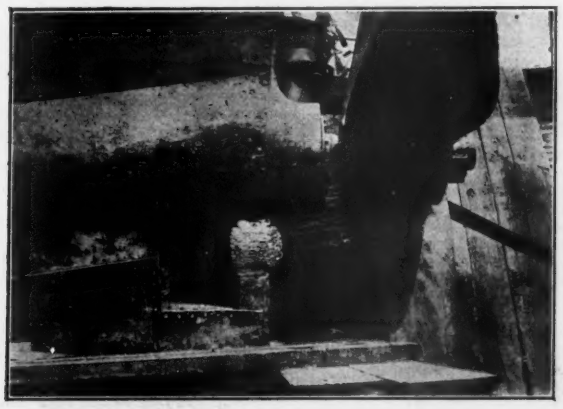

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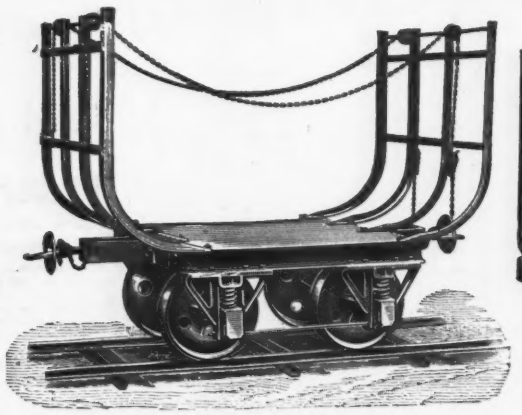

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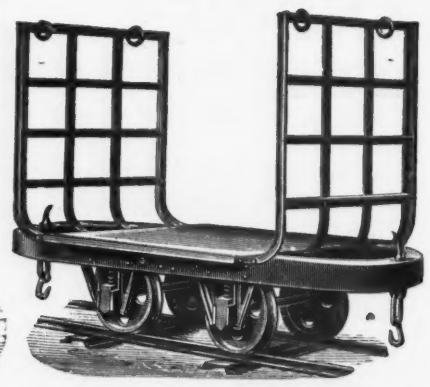

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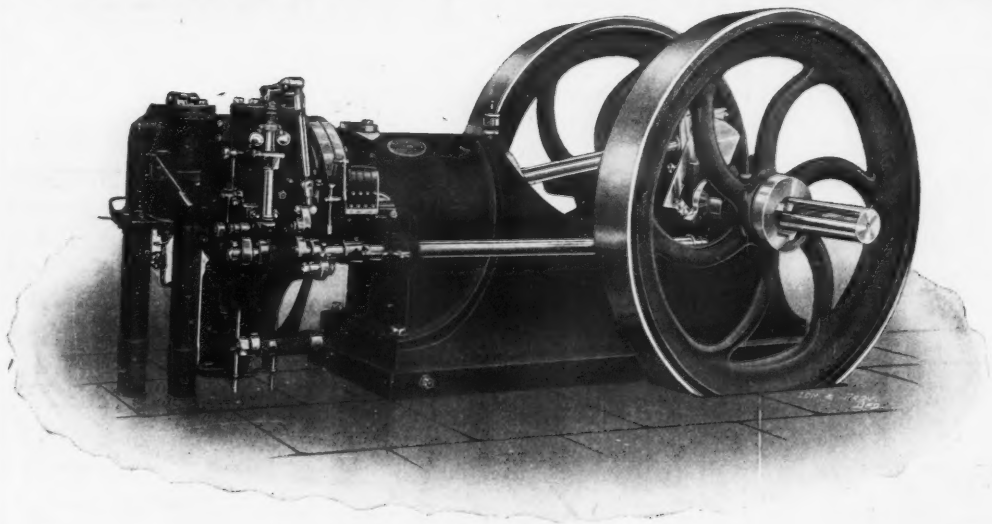

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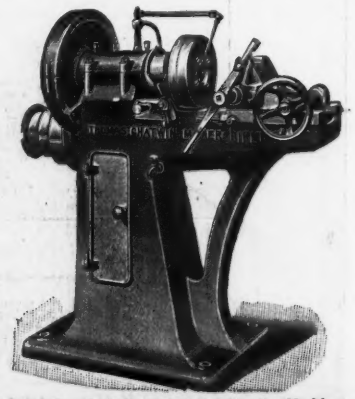

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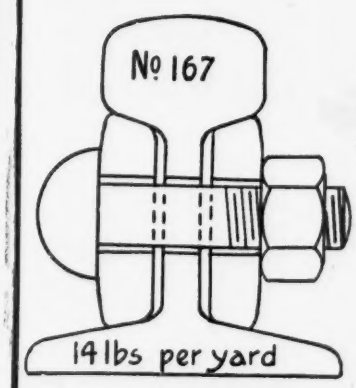
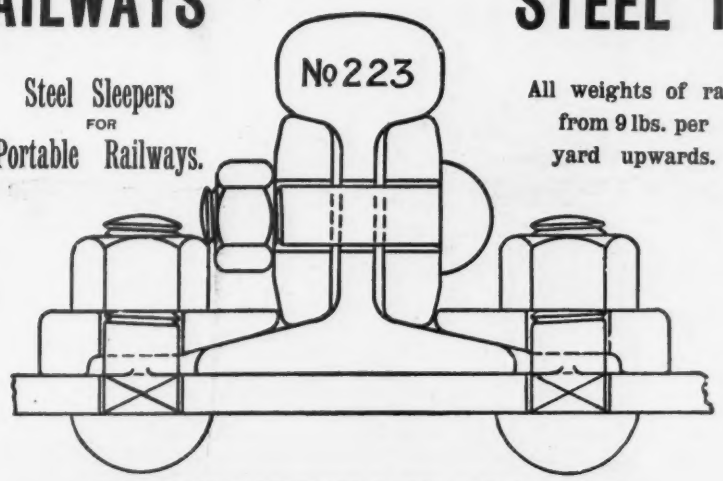
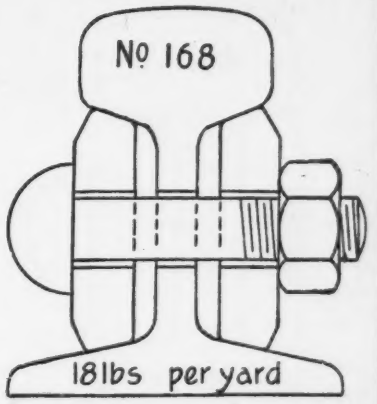


Steel Sleepers FOR Portable Railways.



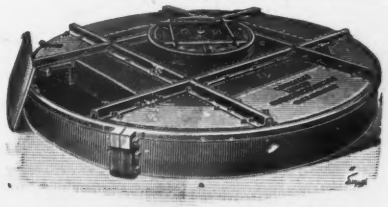
All weights of rail from 9 lbs. per yard upwards.

STEEL TIPPING WAGONS

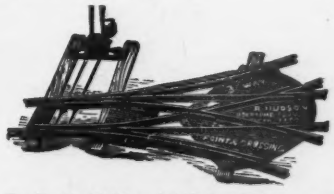


STEEL TROUGH OR CORRUGATED SLEEPER, WITH BOLTED CLIPS.

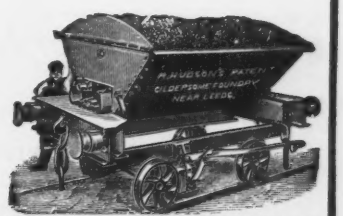
No. E. 96—Patent Double Centre Steel Side Tip Wagon (Diamond Fields Pattern), with jockey for wire rope haulage.



No. E. 115—Self-contained Turntable.

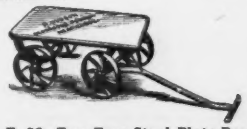


No. E. 11—Right and Left-hand Three-way Steel Point and Crossing.



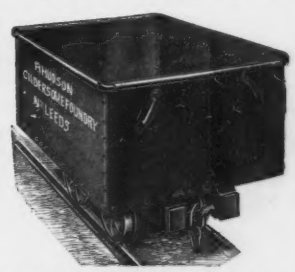
No. E. 59.—Patent Double Side Tip Wagon. To work with ordinary Railway Wagons made to any size. Can be tipped by one man.

No. E. 1—Patent Steel End Tip Wagon.

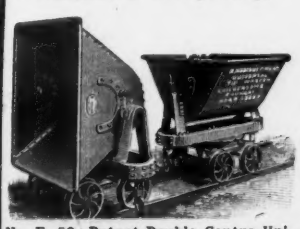


No. E. 22—Two Tons Steel Plate Bogie. "Practically Indestructible." Always in Stock. Platform about 56in. long by 30in. wide. Height 23in. Weight about 4 cwts. 18in. Steel Wheels.

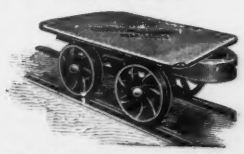
No. E. 76—Hand Trolley, made to carry any weight, or to suit any rail gauge.



No. E. 101—Steel Plate Colliery Truck.

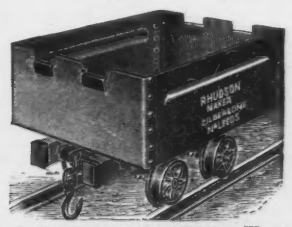


No. E. 50—Patent Double Centre Universal Tip Wagon, tipping either Endways or Sideways at will.

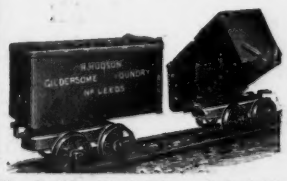


No. E. 58—Steel Plate Bogie.

No. E. 86—Steel Tip Buckets.



No. E. 104—Pressed Steel Mining Wagon.



No. E. 97—Steel Side and End Tip Wagon, with Flapping Door (for hand use).

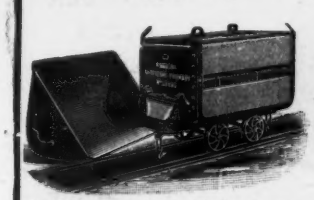
No. E. 162—Patent Steel Double Side Tip Wagon, with screw brake and platform.

No. E 15—Steel Cage. With Safety Grippers and Fallers complete.

5ft. × 5ft. HEARTH, about 16½ cwts.

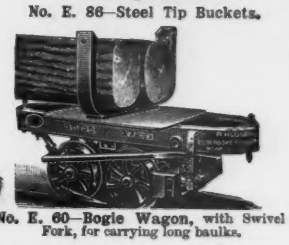
DOUBLE HEARTH, about 18½ cwts.

3½ft. × 4ft. HEARTH, about 10½ cwts.

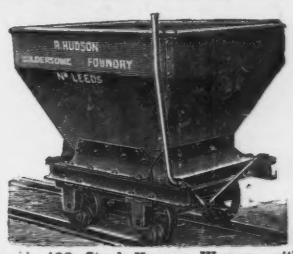


No. E. 193—Crane Brick Box to fit on standard side tip wagon underframe.

No. E. 171—Coke-charging Barrow, with end door.



No. E. 60—Bogie Wagon, with Swivel Fork, for carrying long baulks.



No. E. 108—Steel Hopper Wagon, with sliding door worked by lever.

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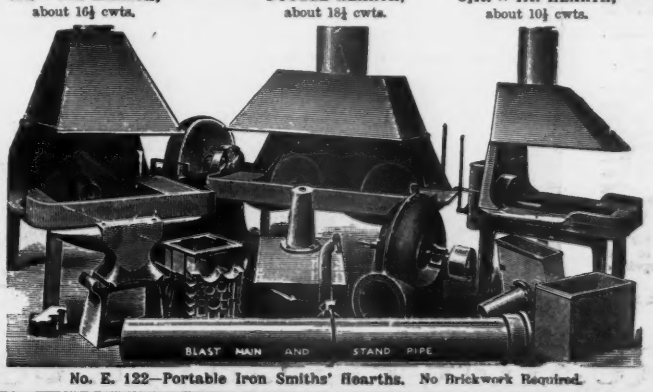

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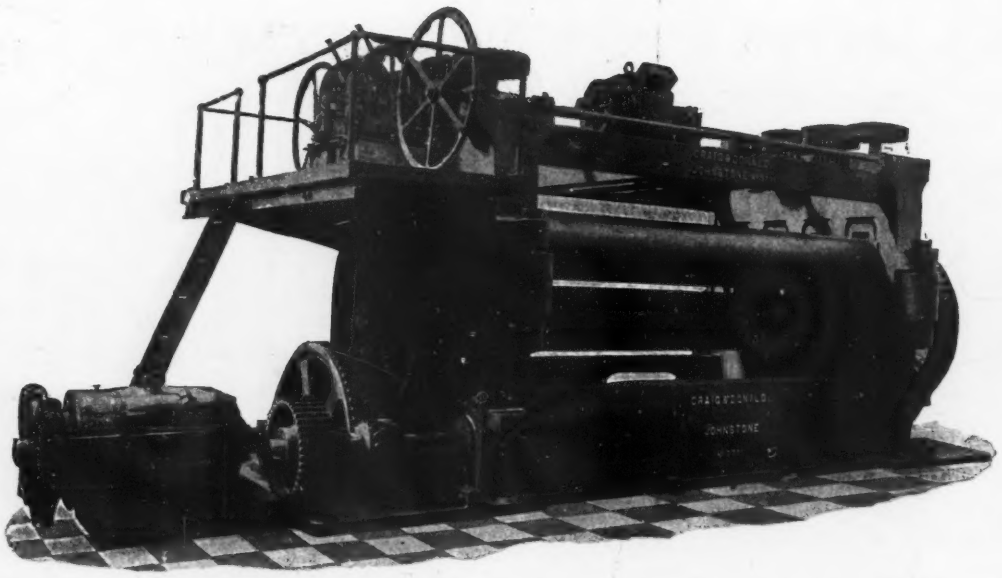

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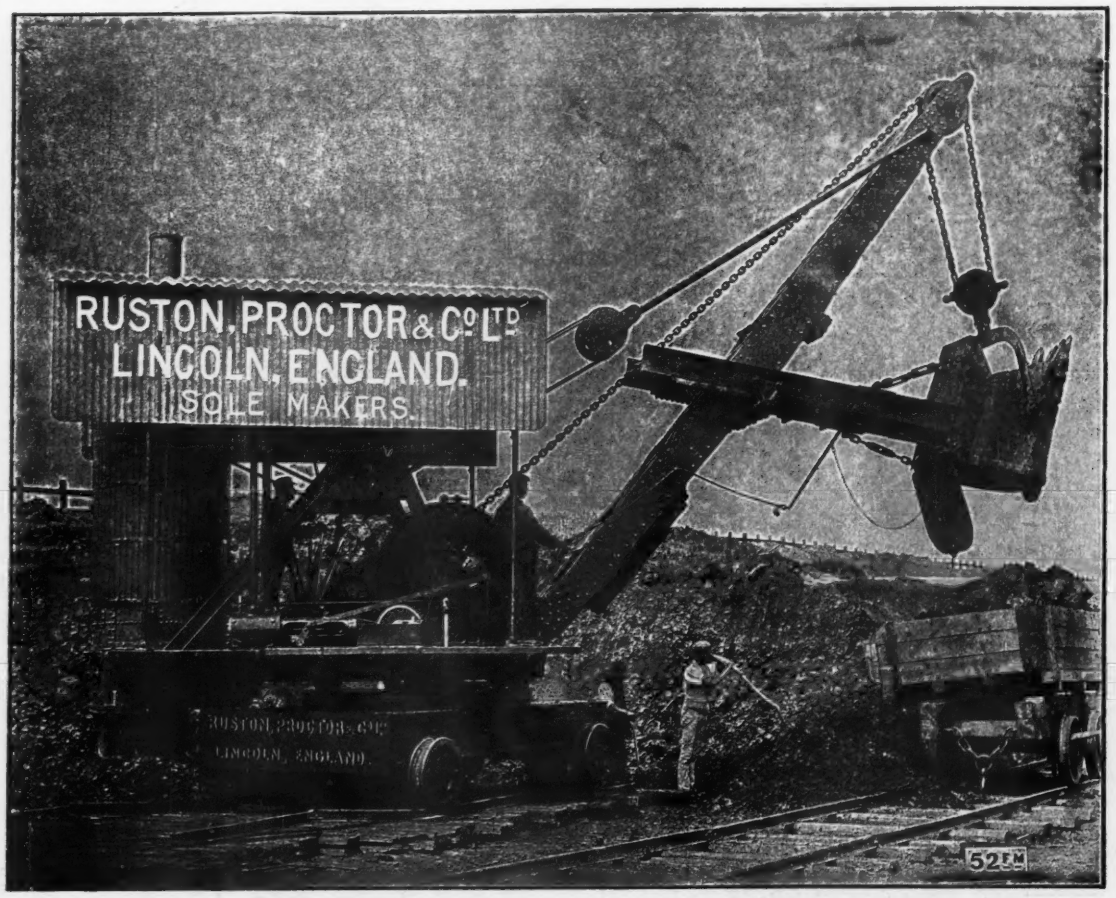

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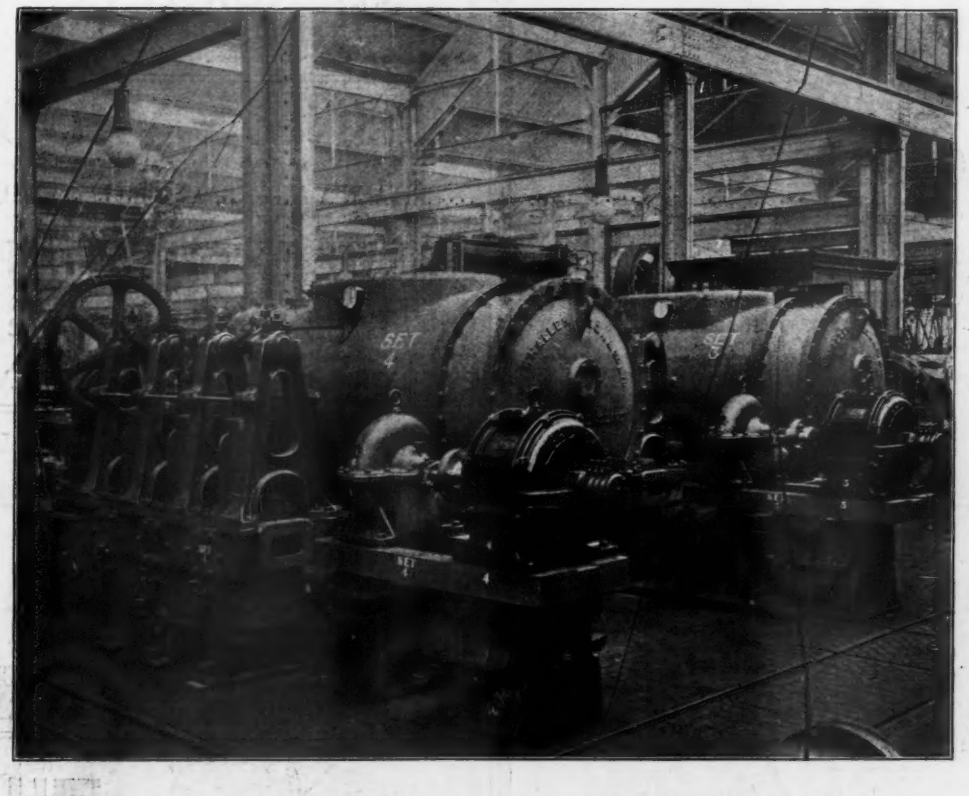

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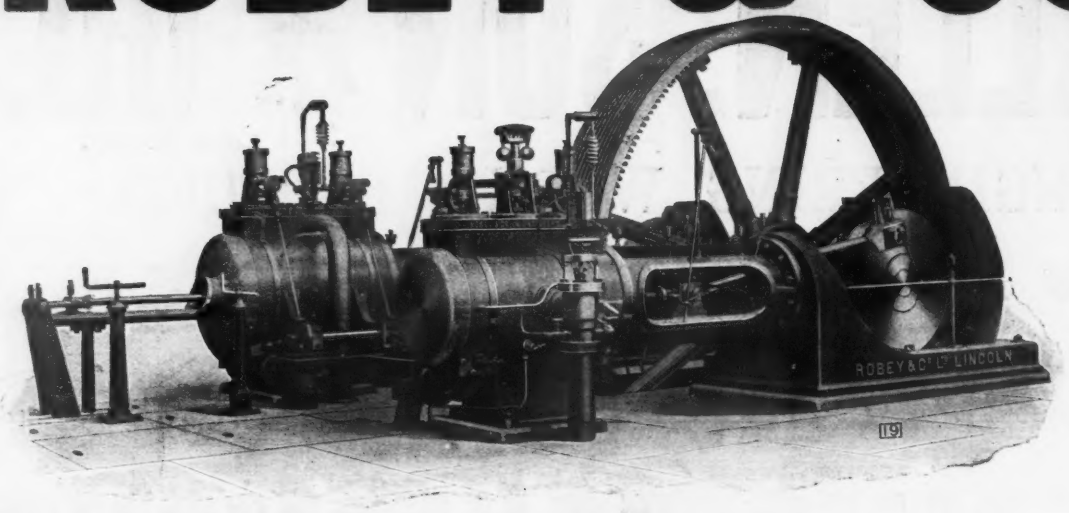

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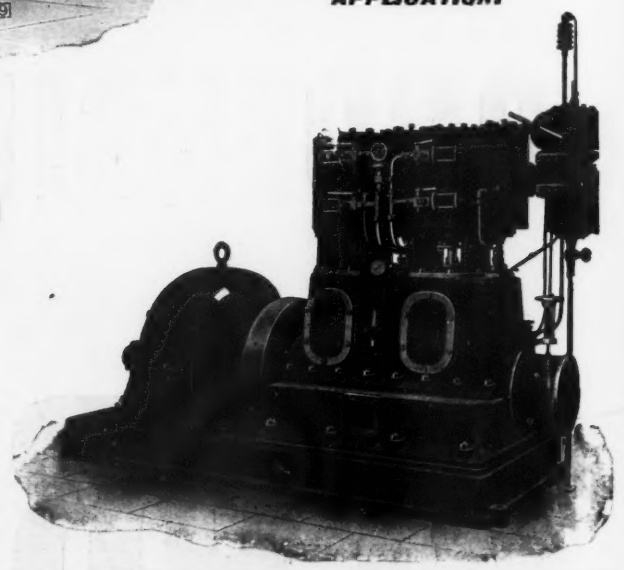

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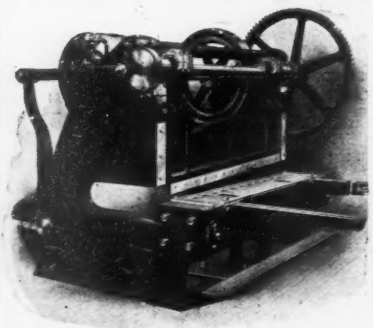

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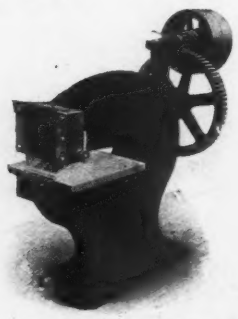

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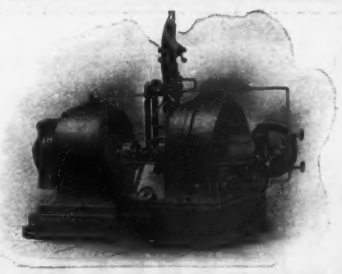

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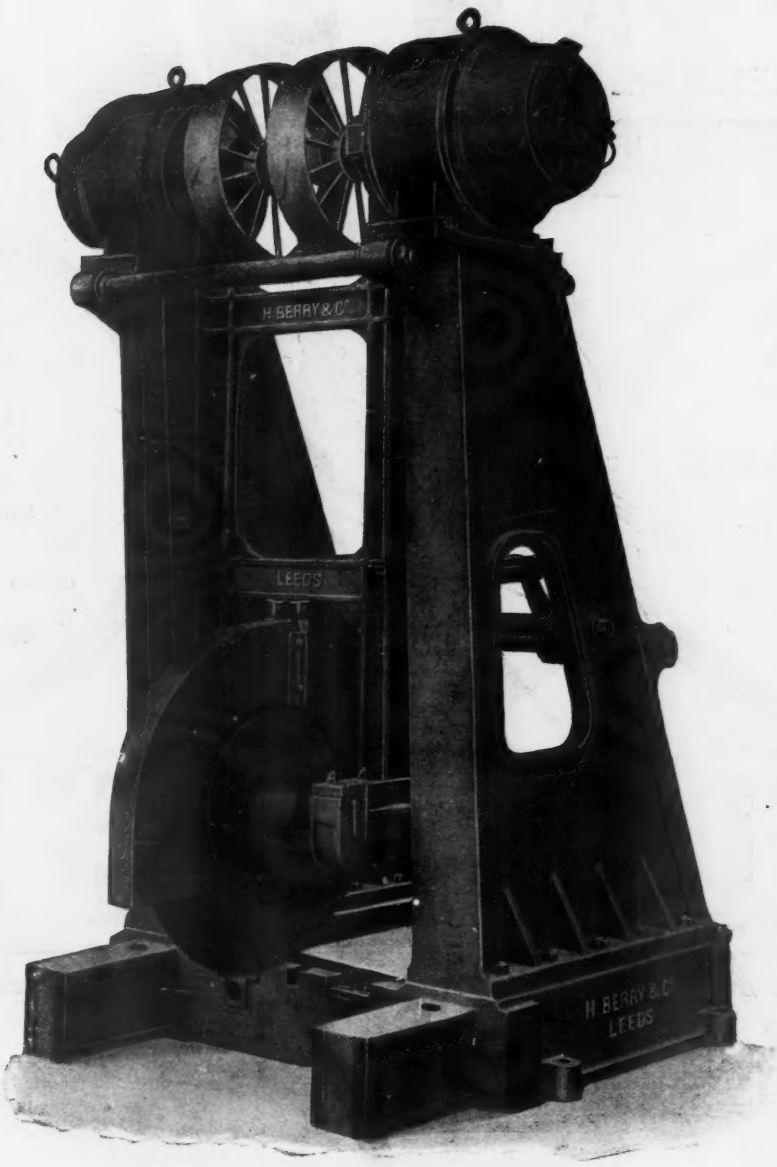

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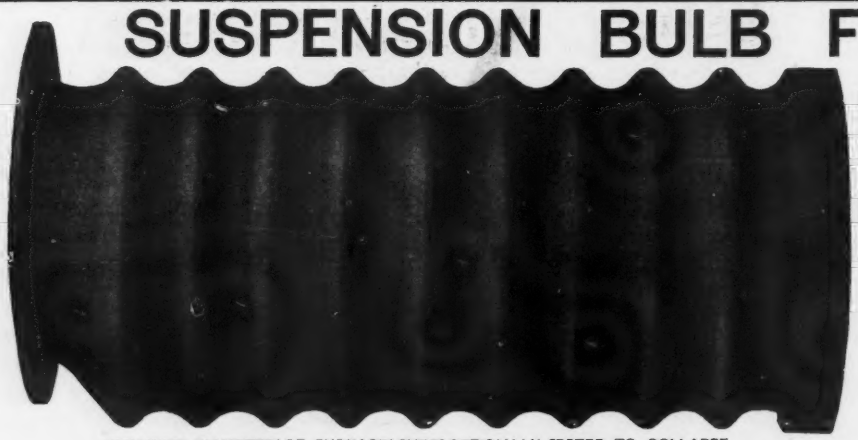

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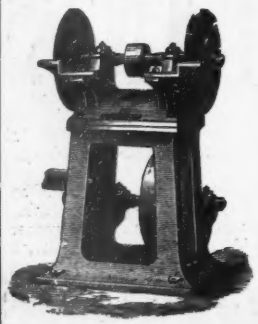

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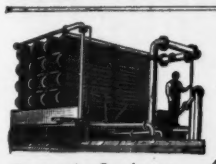

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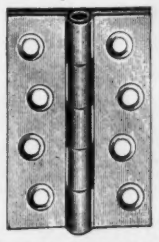

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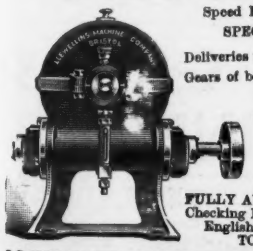

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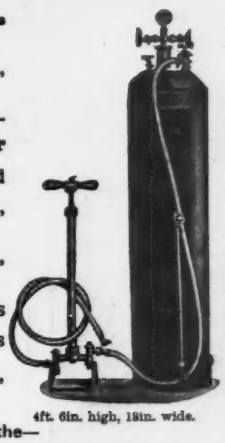

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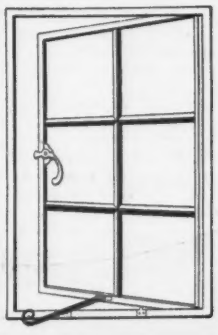

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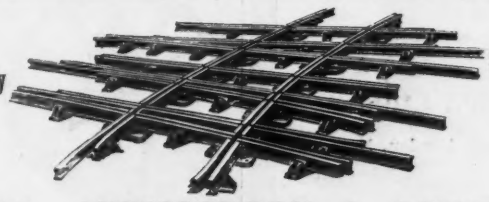

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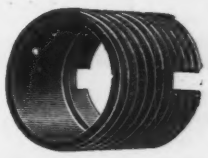

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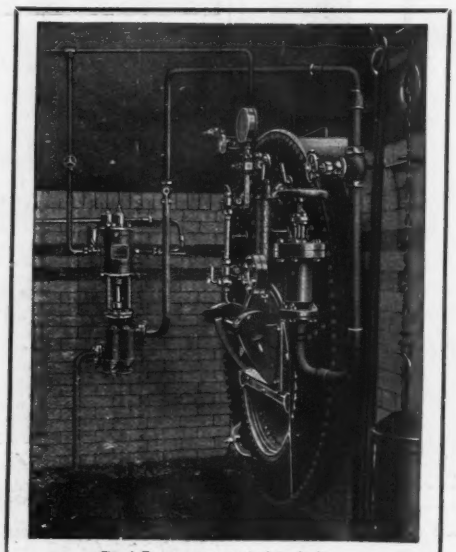

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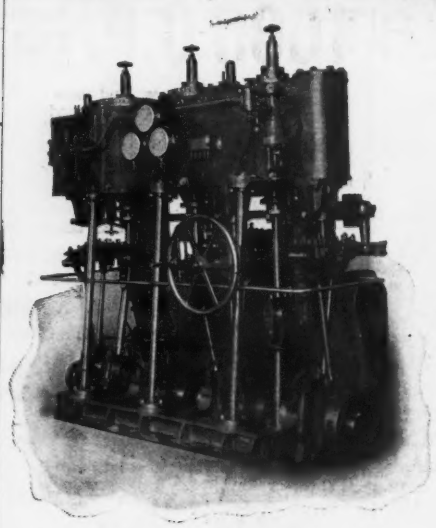

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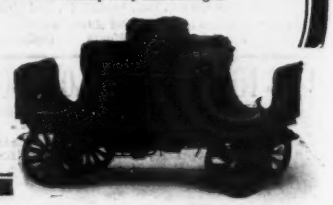

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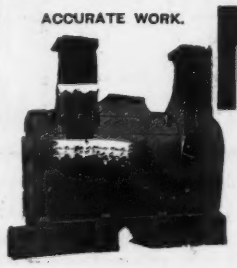

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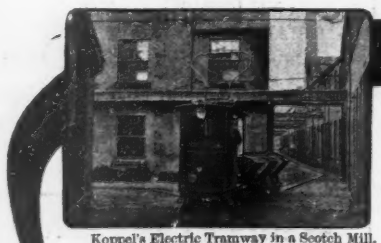

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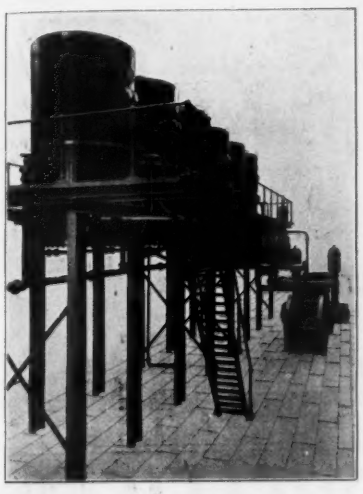

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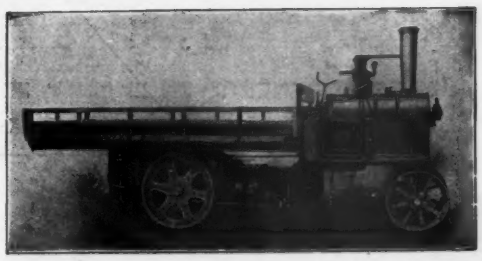

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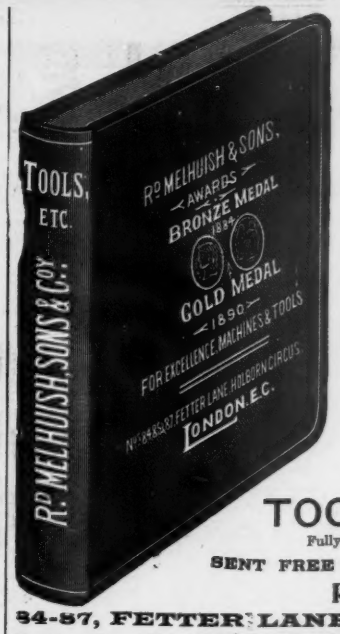

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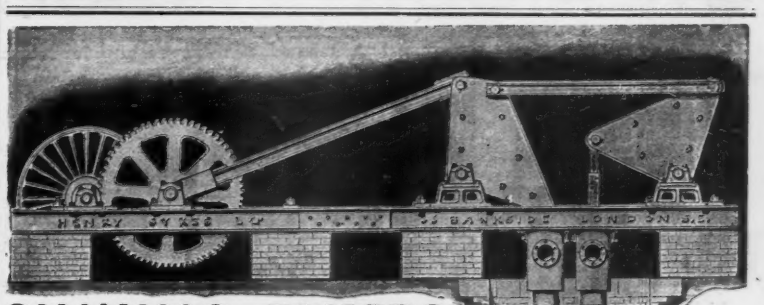

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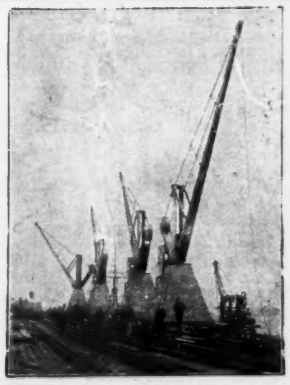

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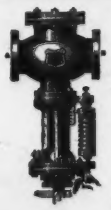

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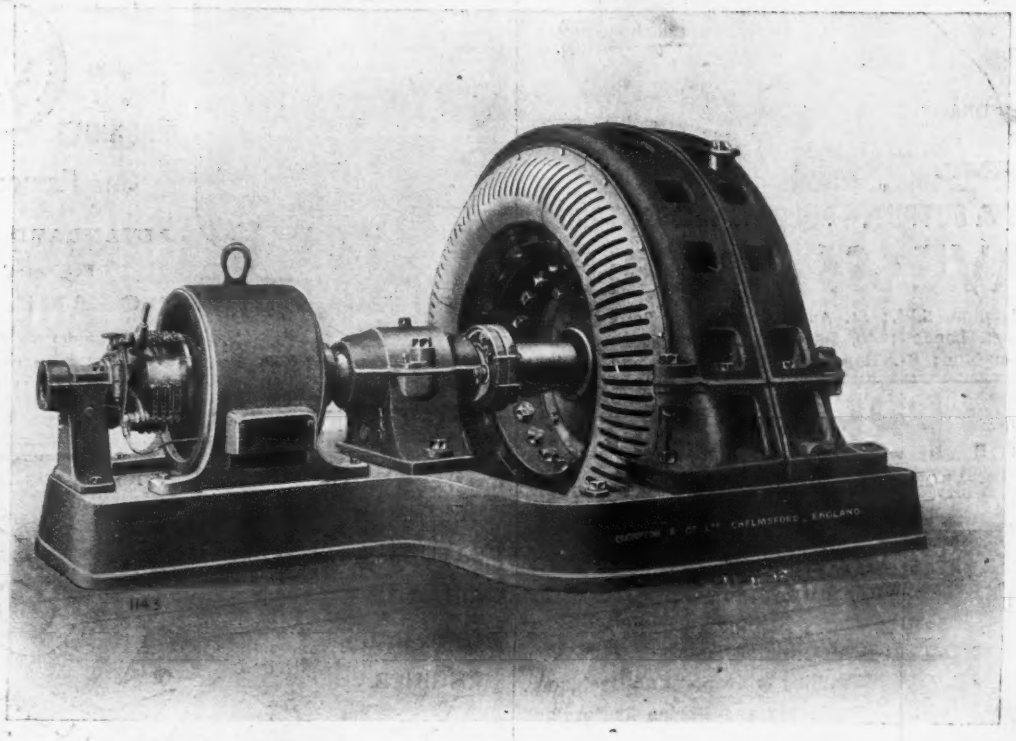

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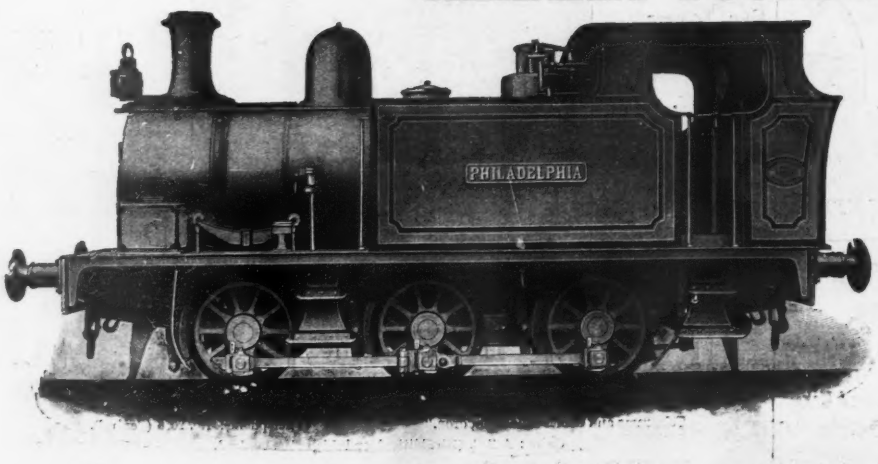

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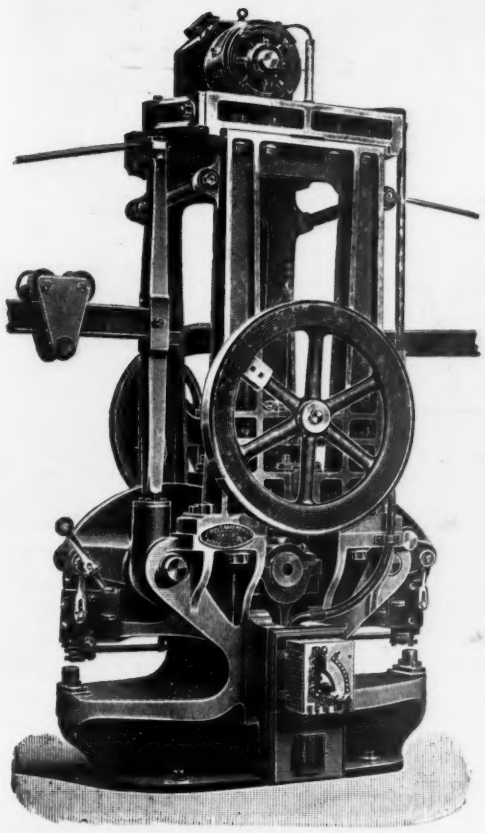

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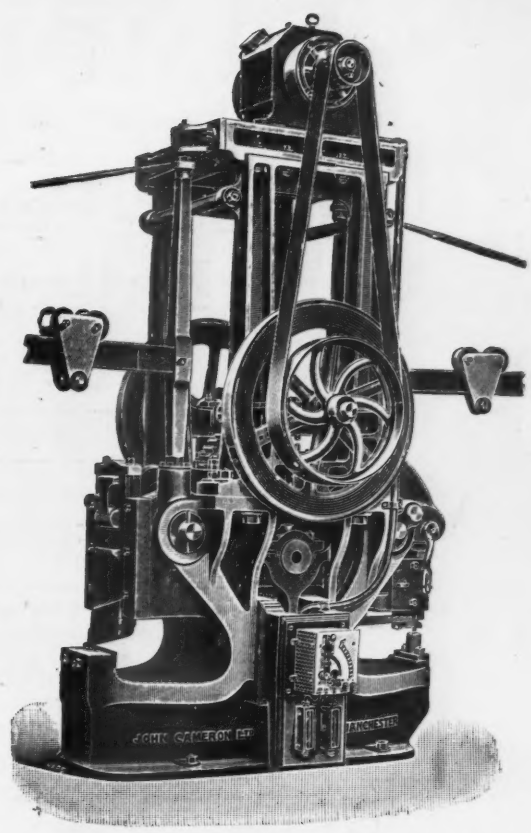

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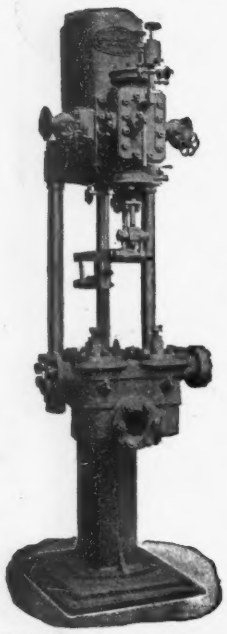

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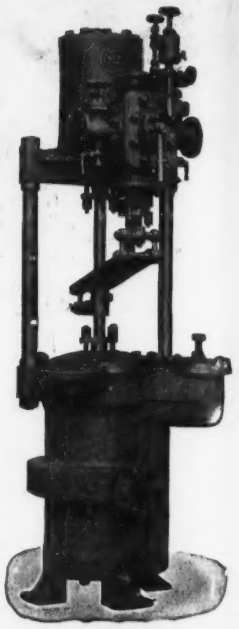

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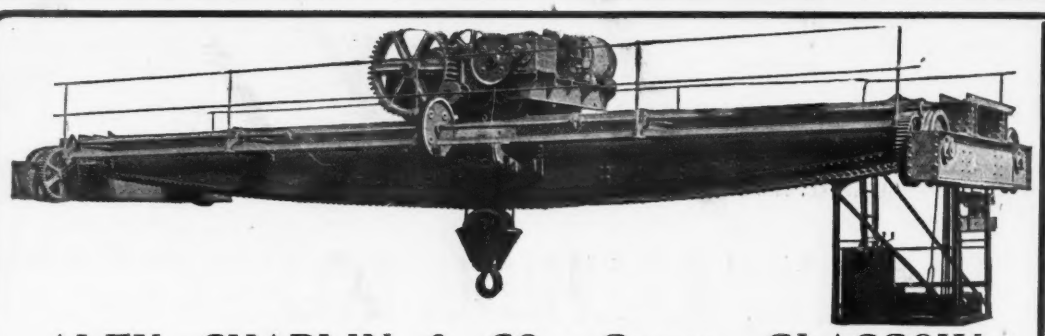

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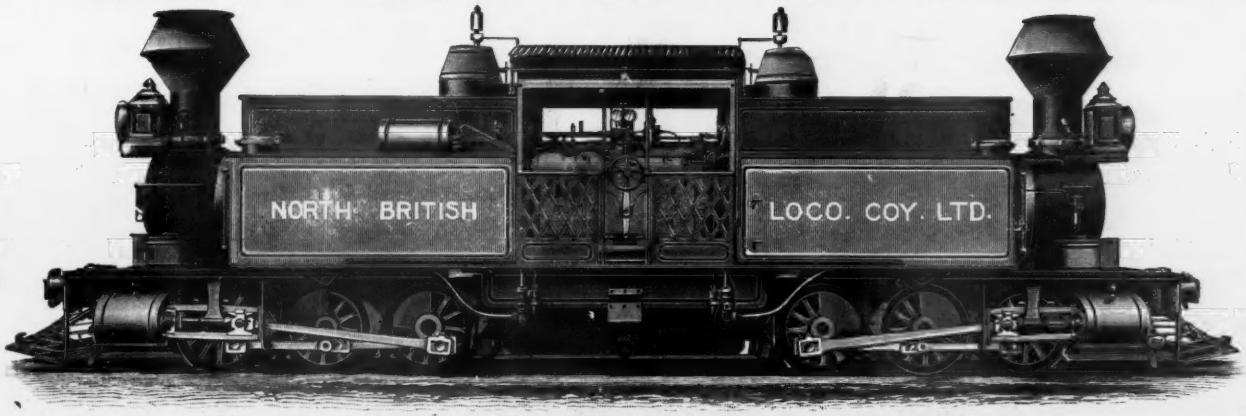

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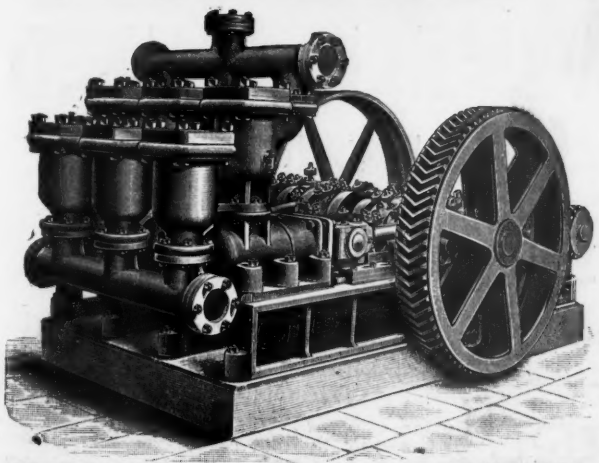

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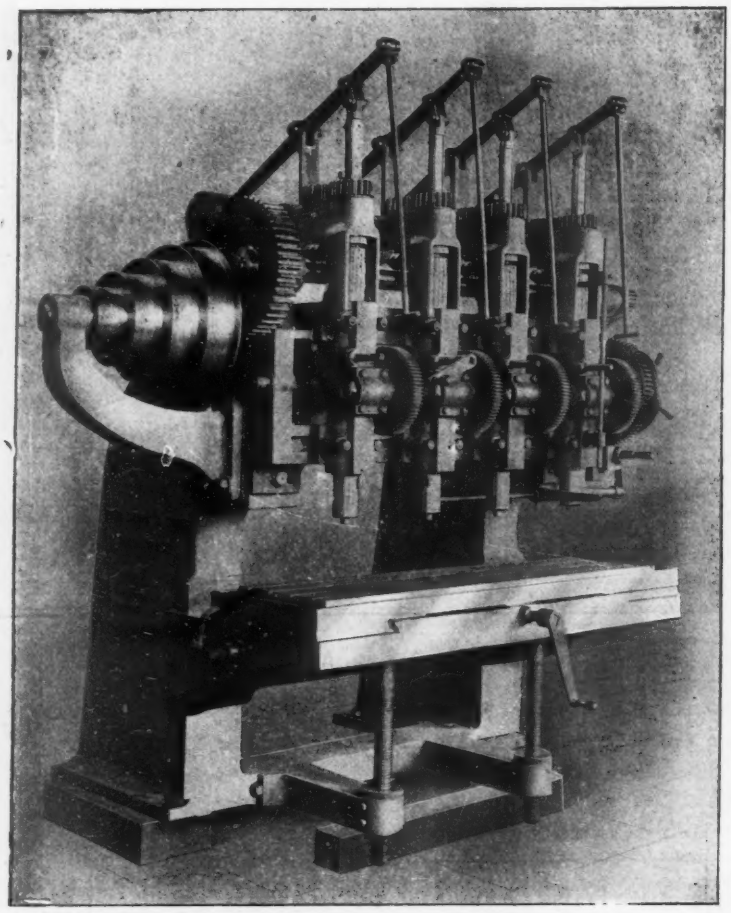

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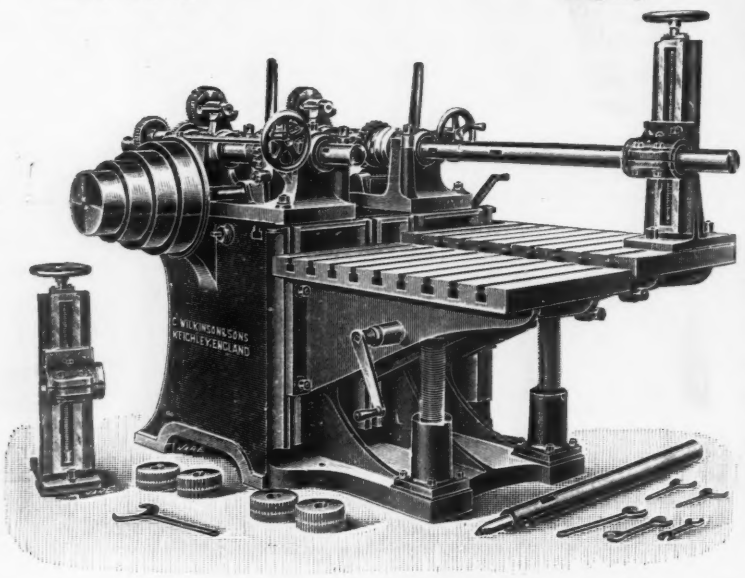

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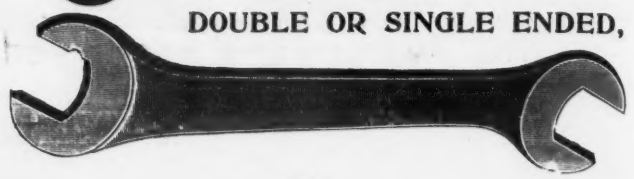

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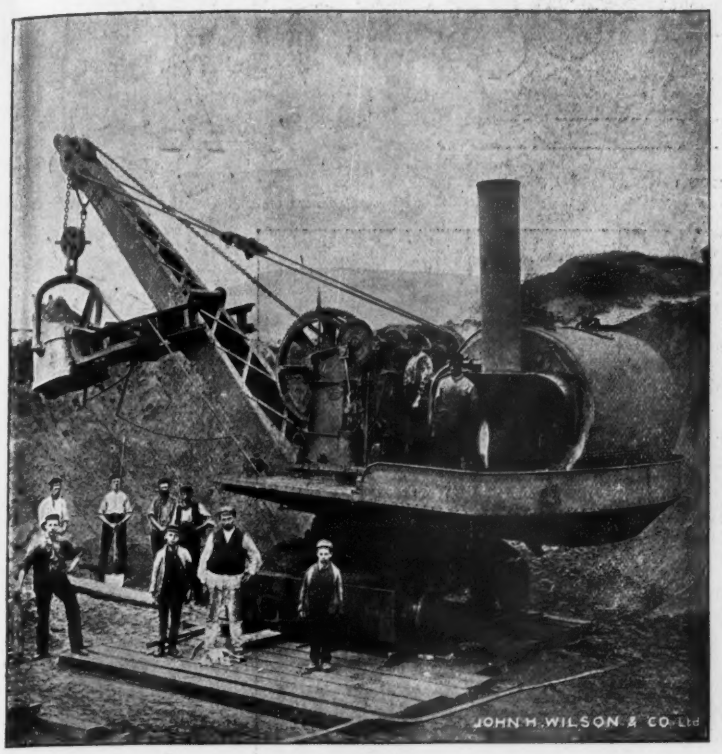

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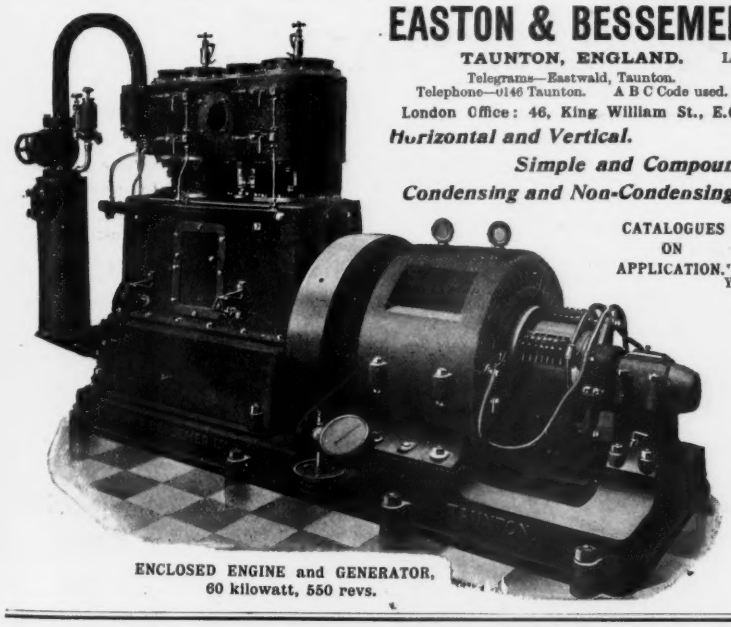

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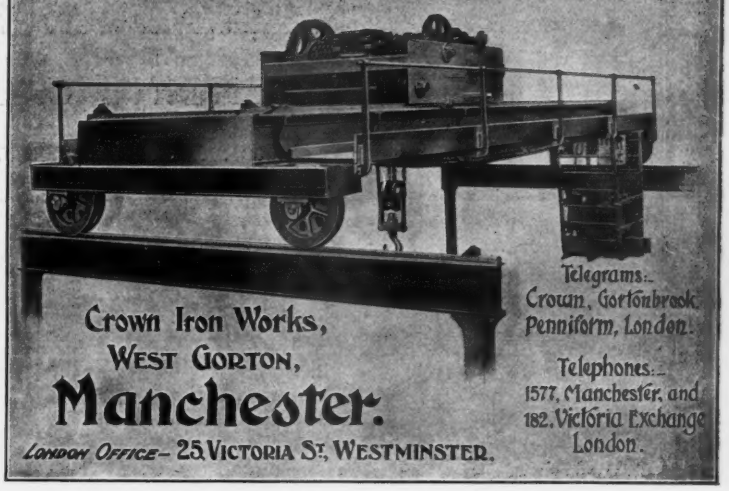

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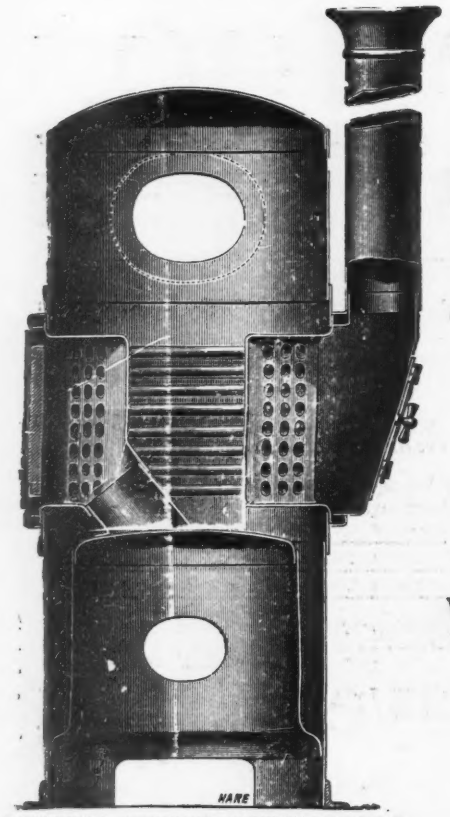

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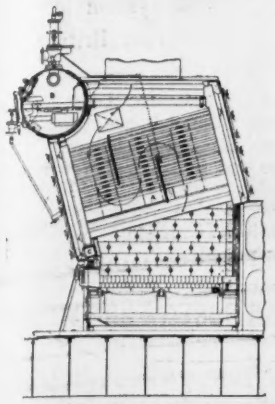

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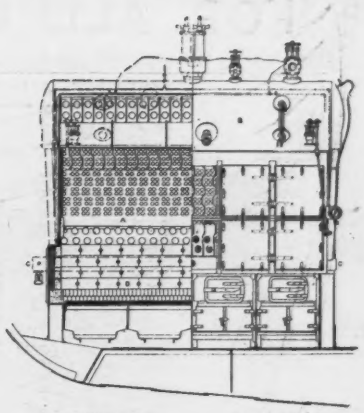

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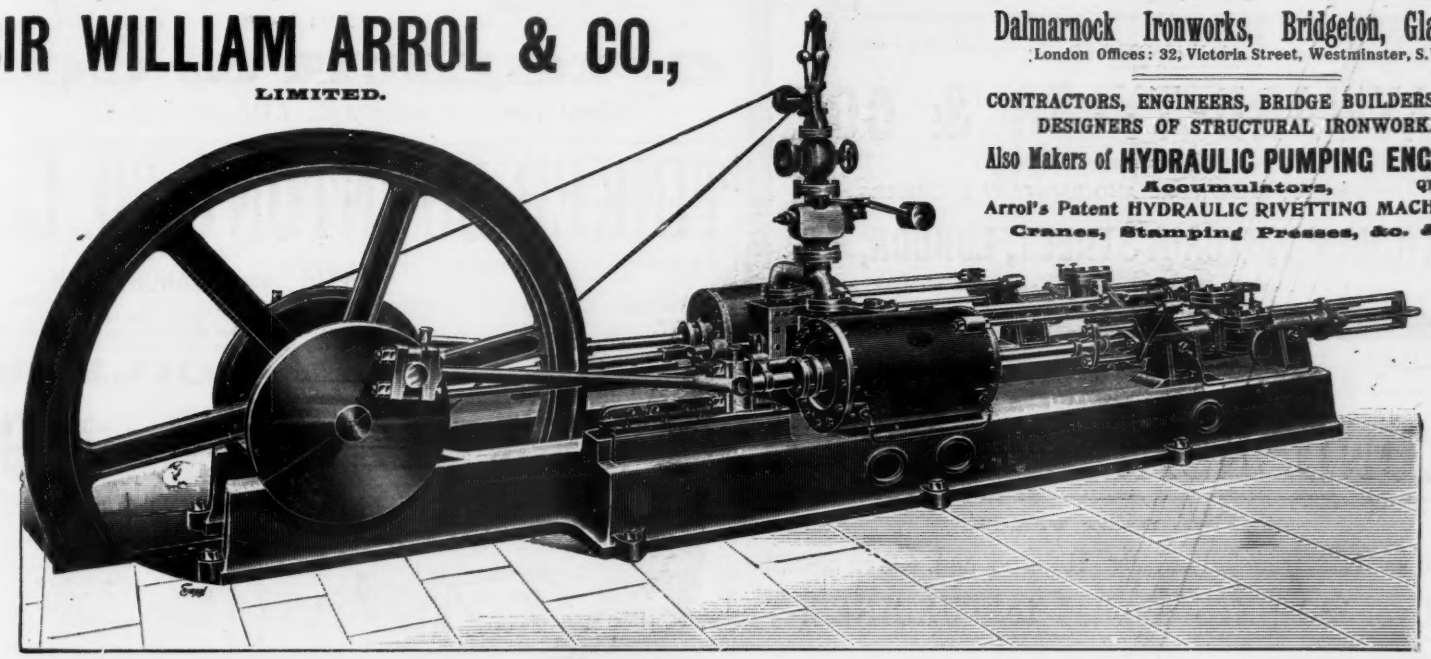

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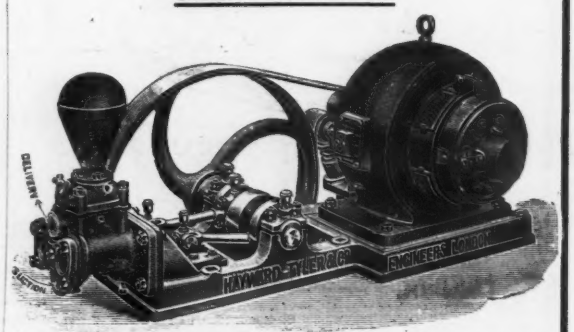

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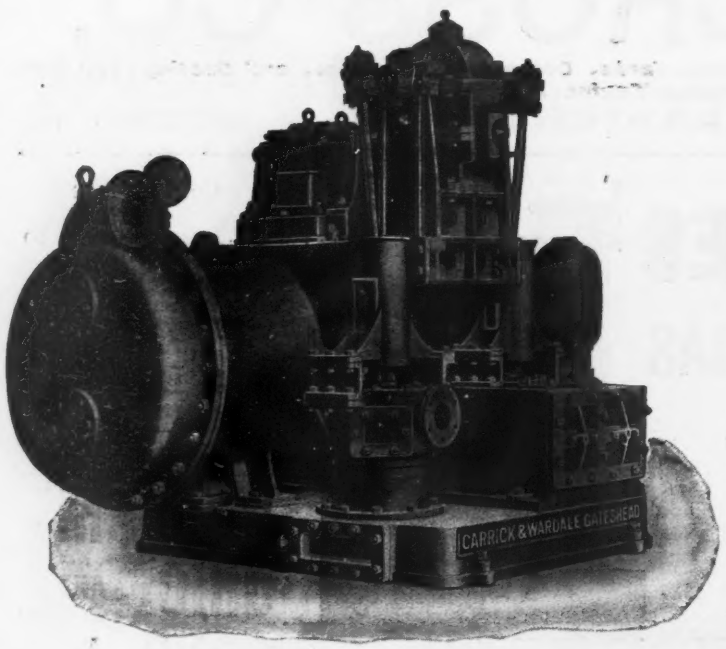

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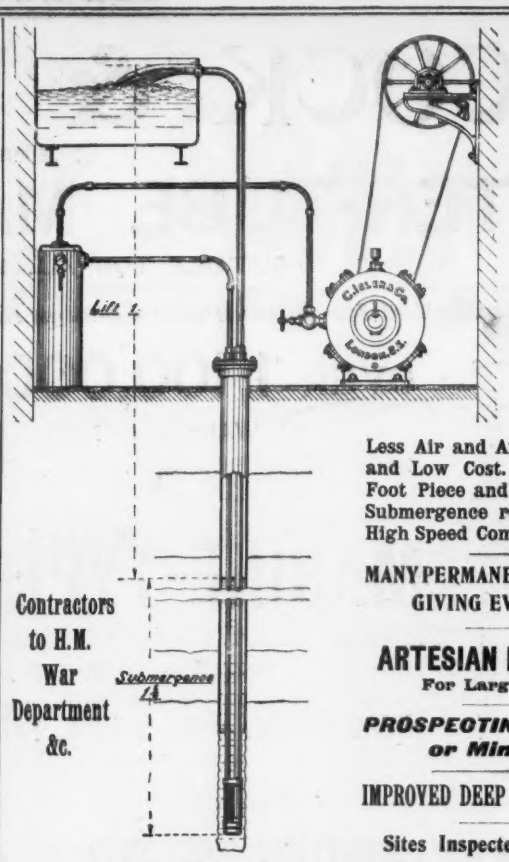

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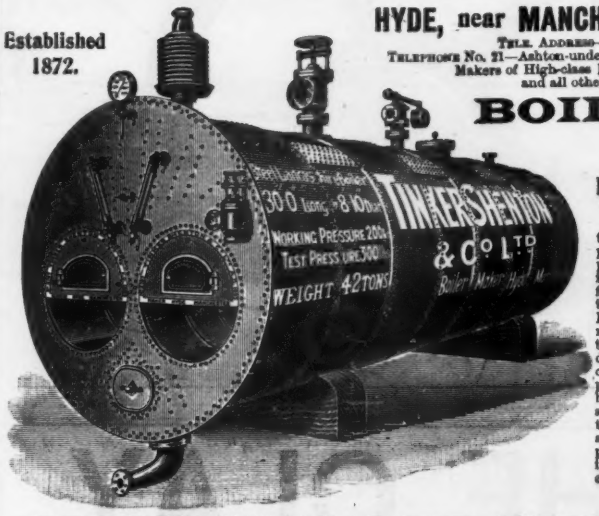

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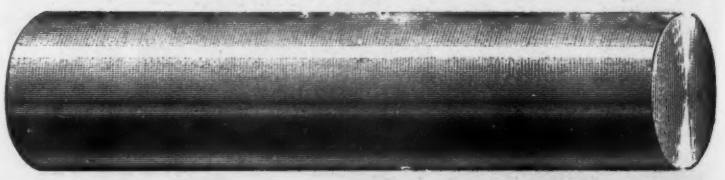

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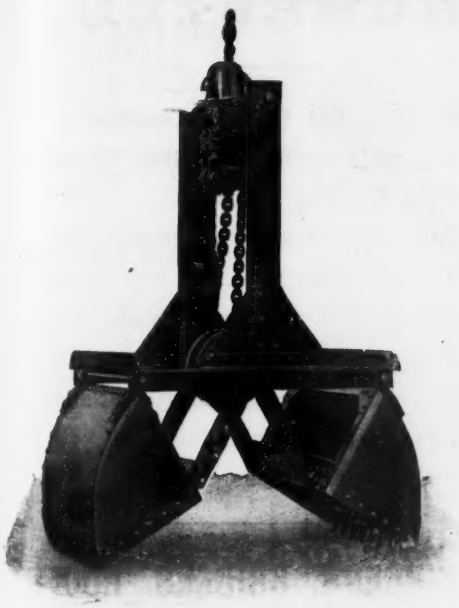

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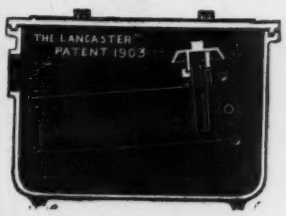

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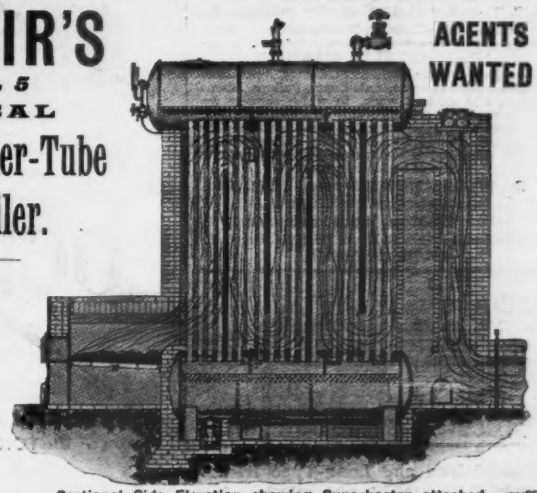

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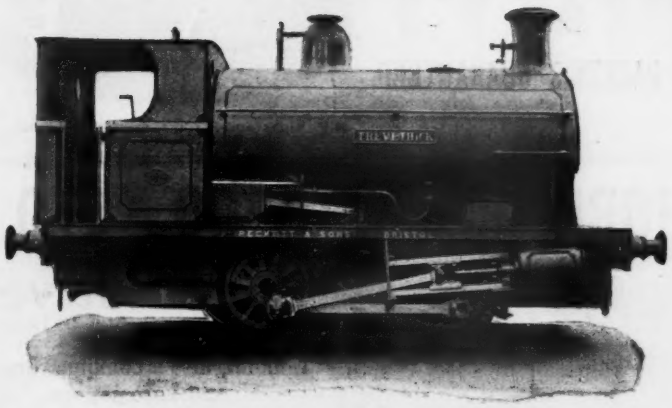

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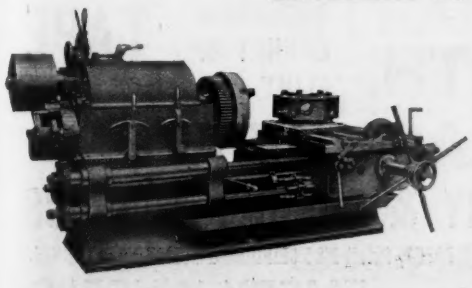

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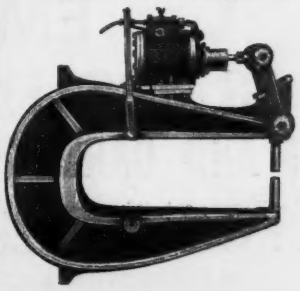

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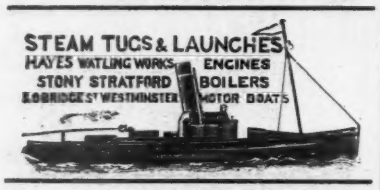

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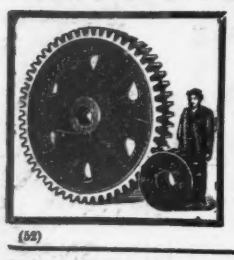

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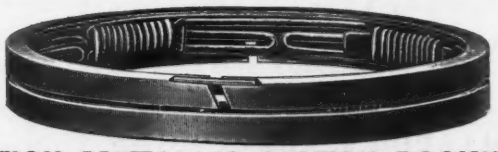

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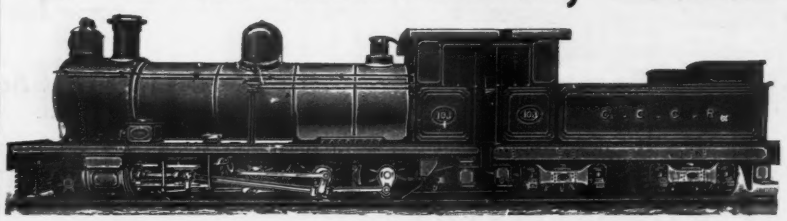

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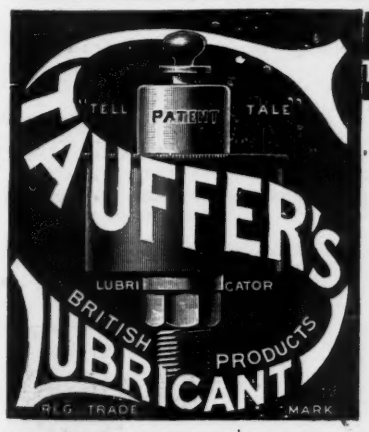

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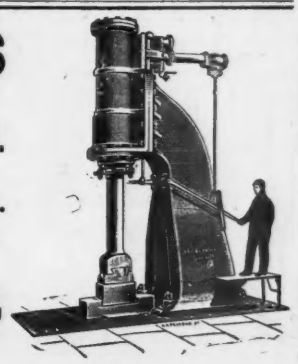

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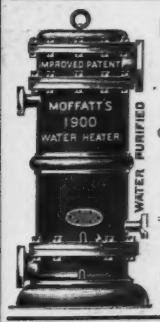

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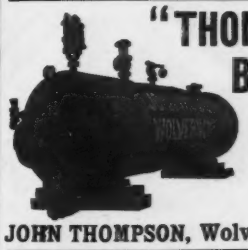

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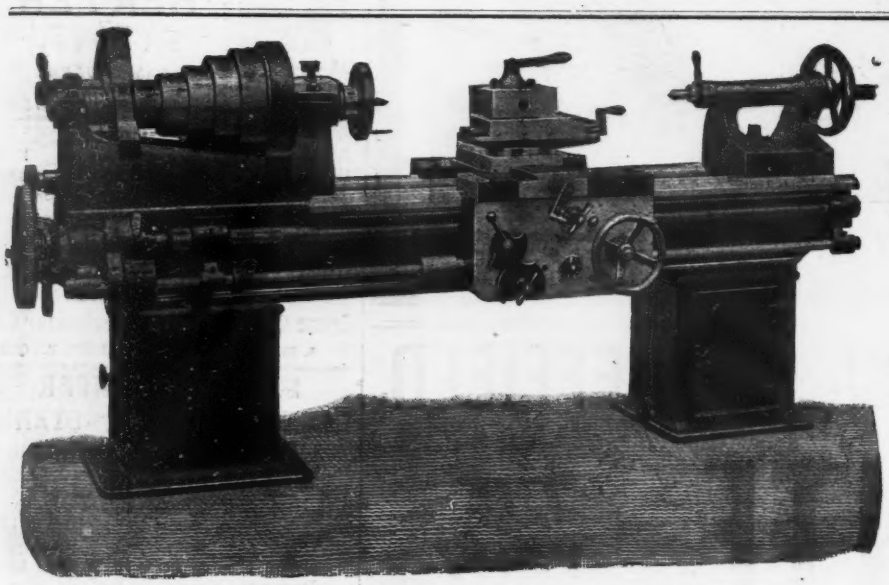

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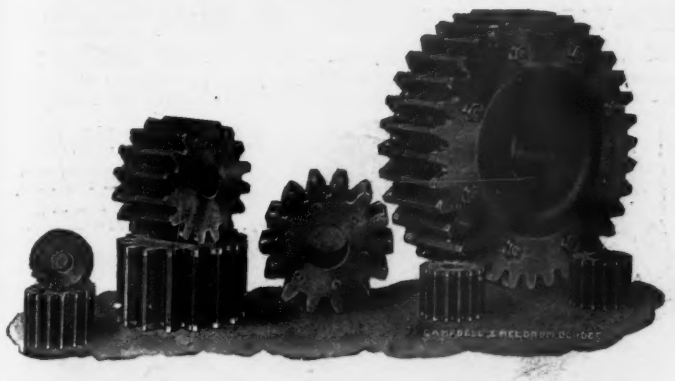

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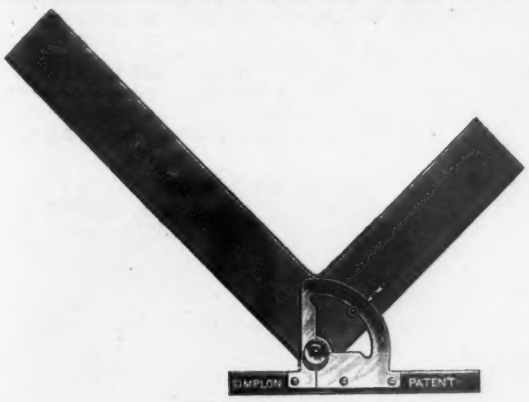

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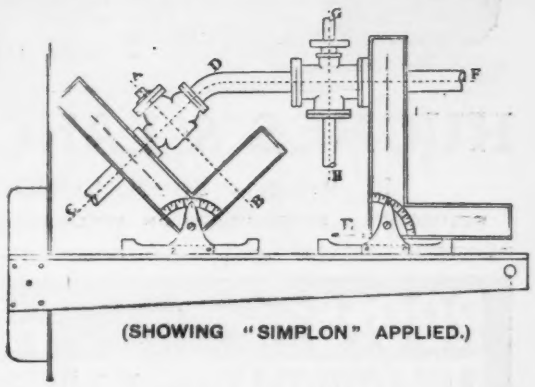

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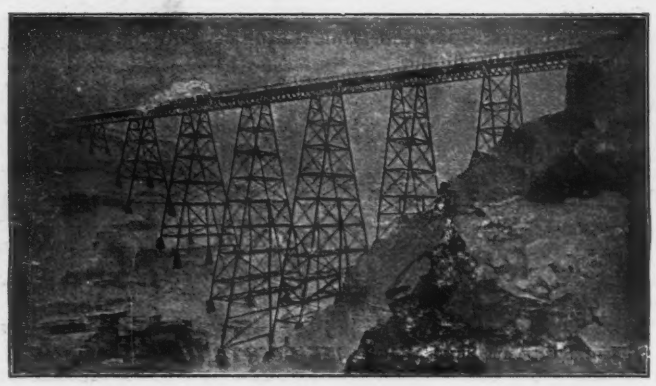

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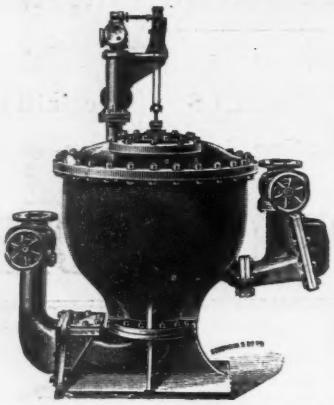

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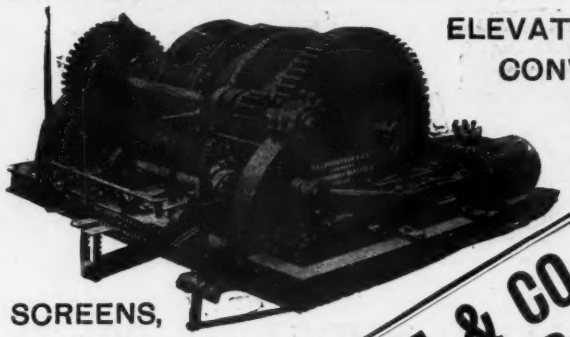

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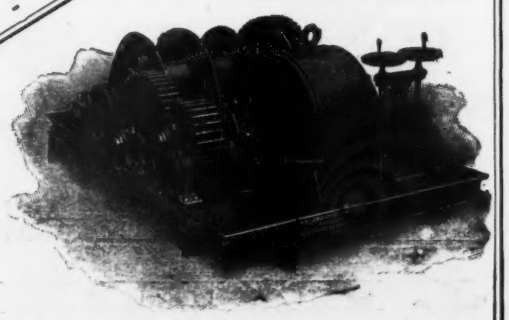

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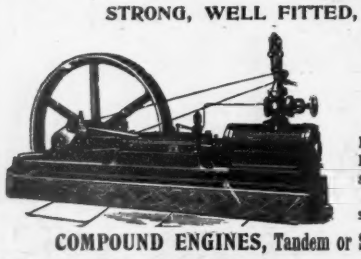

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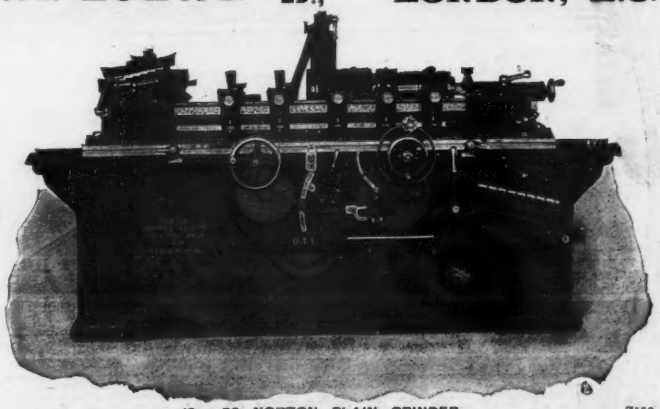

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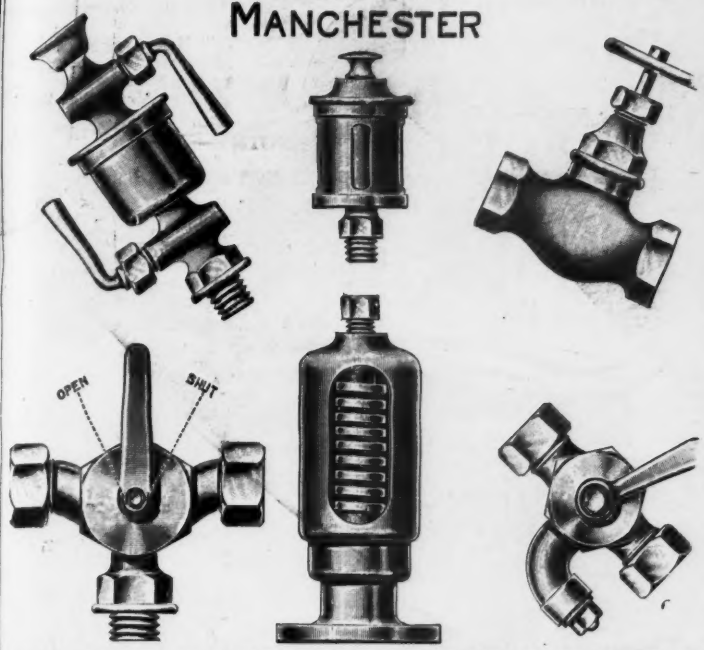

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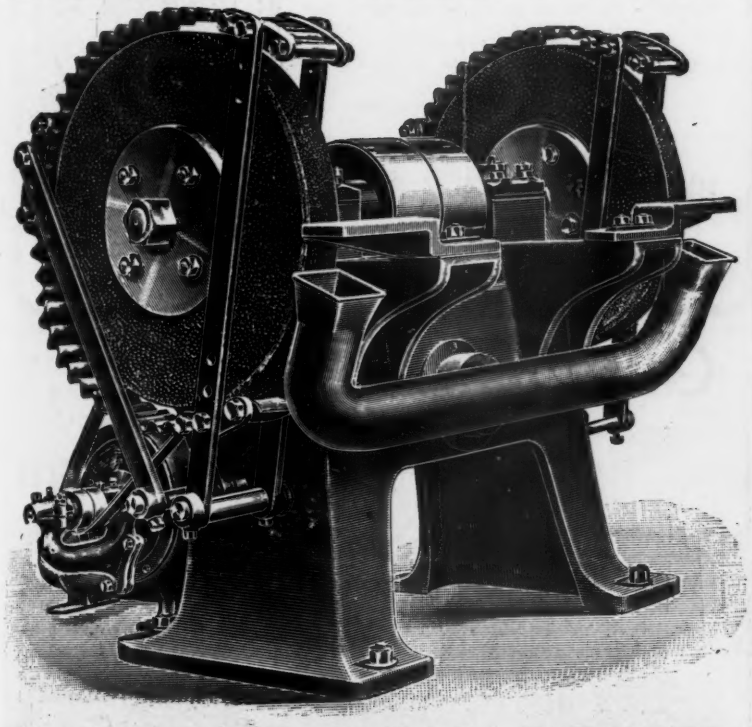

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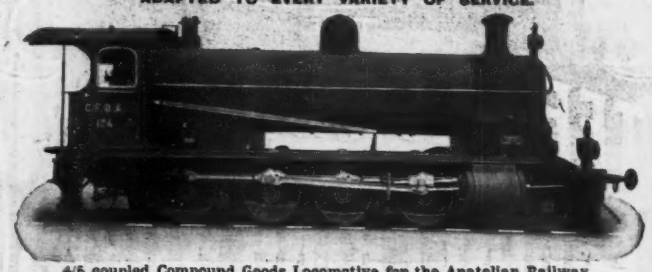

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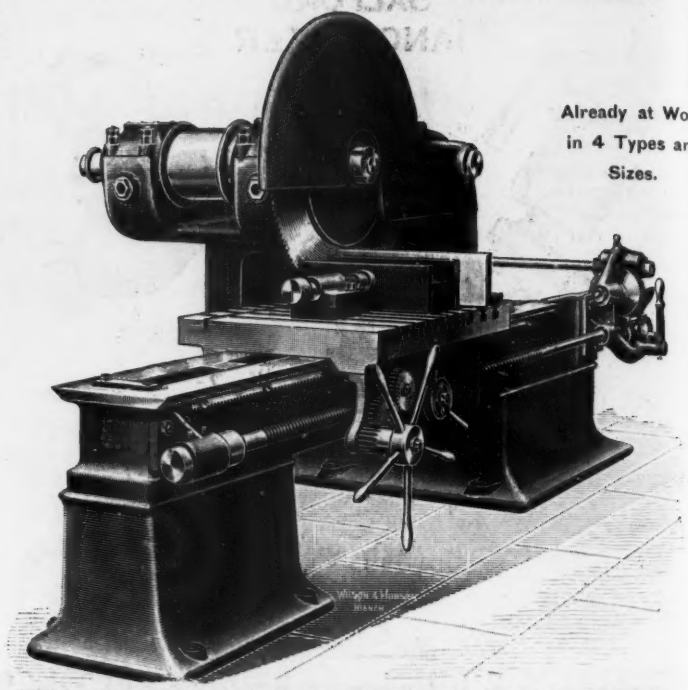

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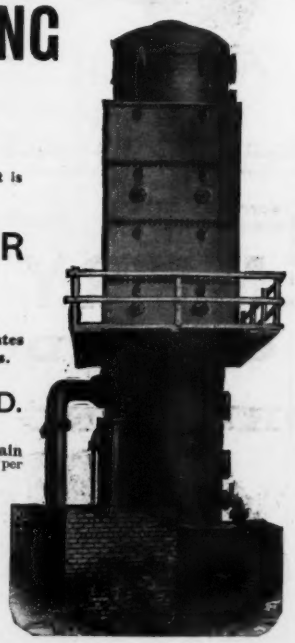

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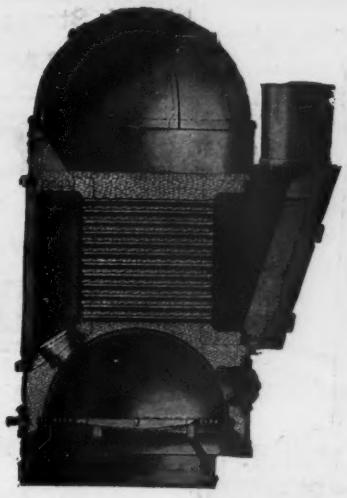

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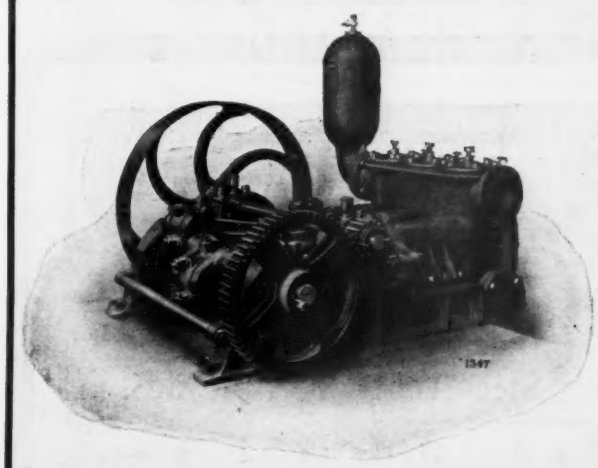

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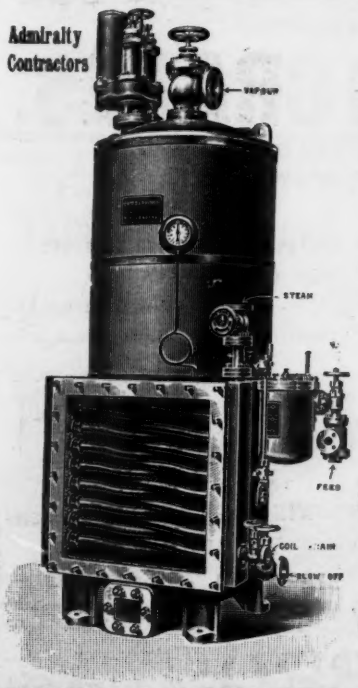

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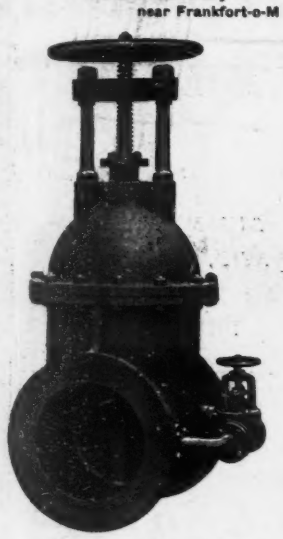

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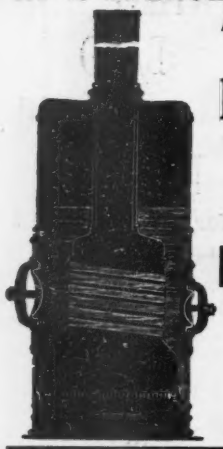

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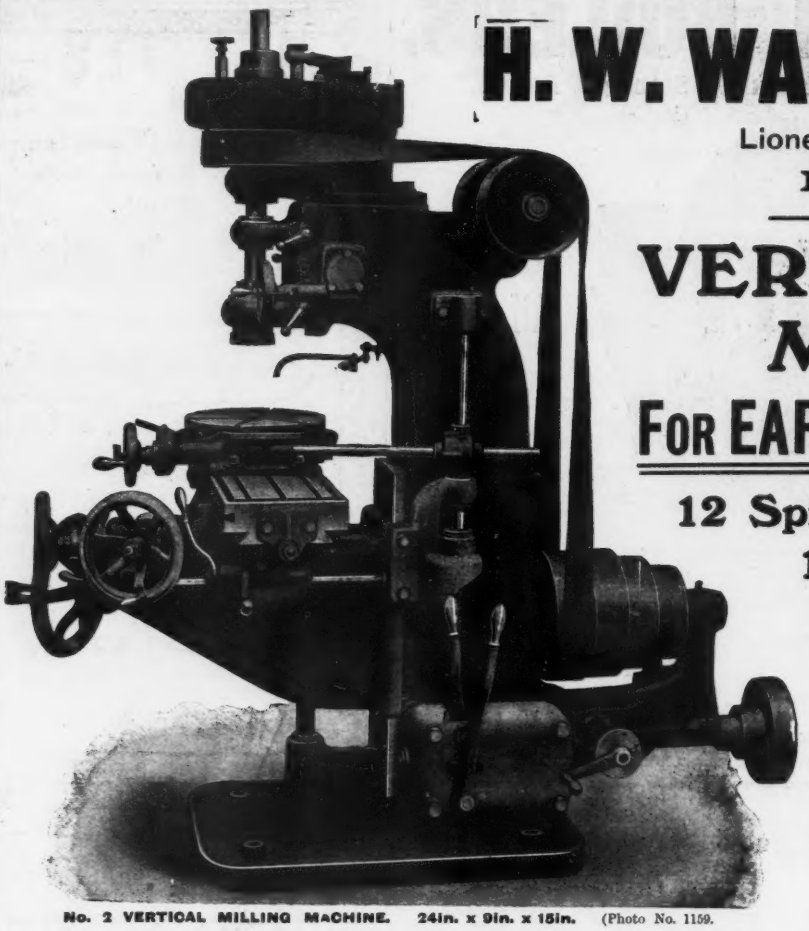

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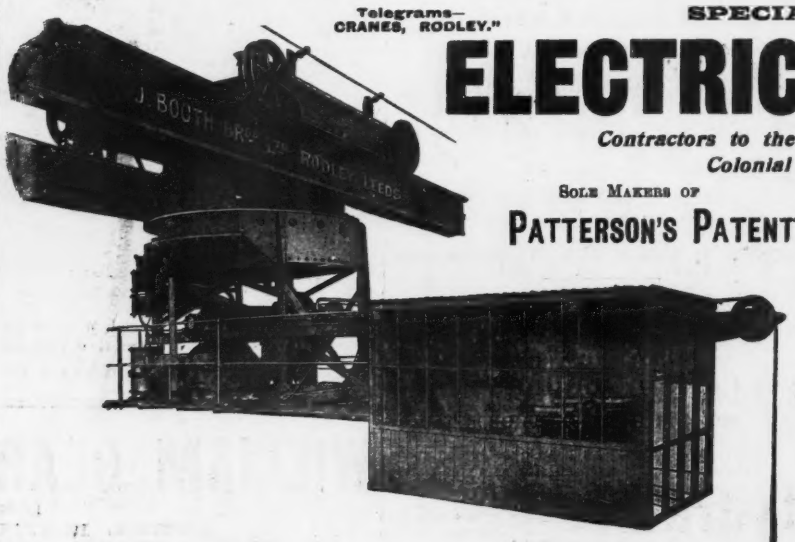

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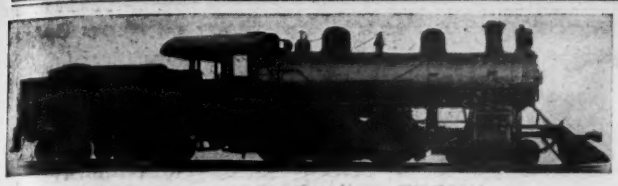

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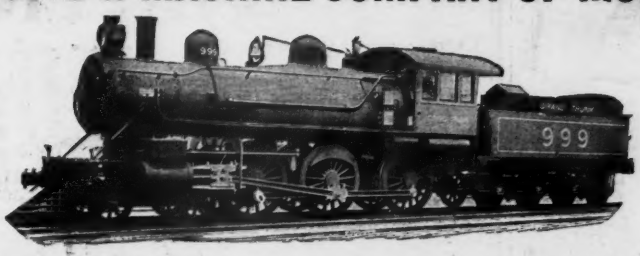

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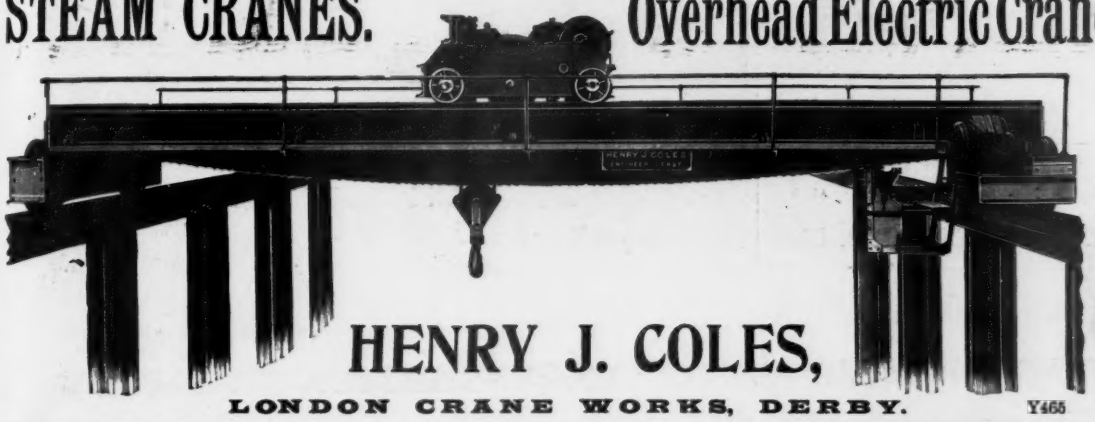

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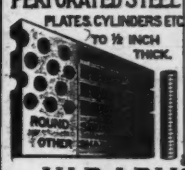

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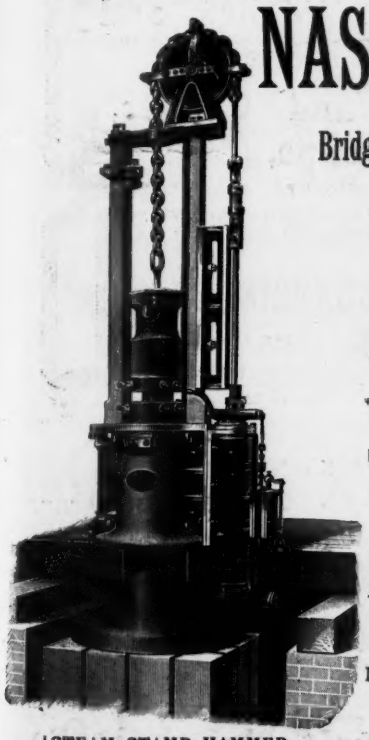

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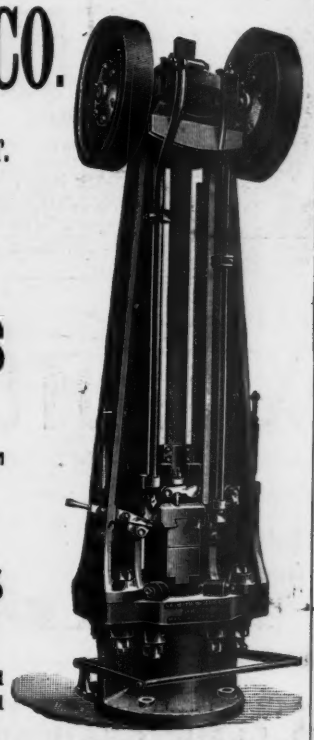

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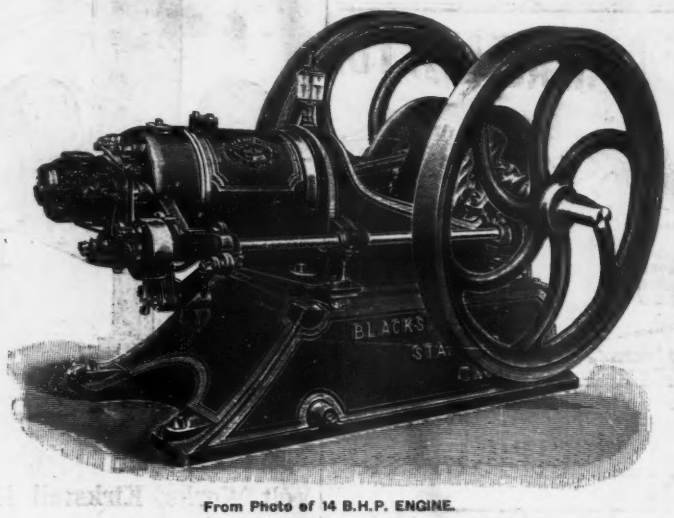

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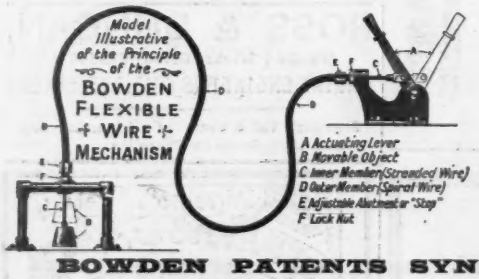
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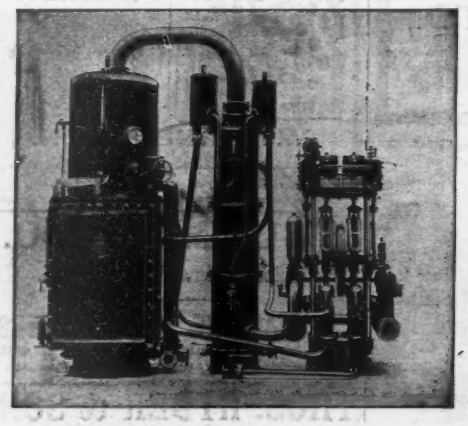

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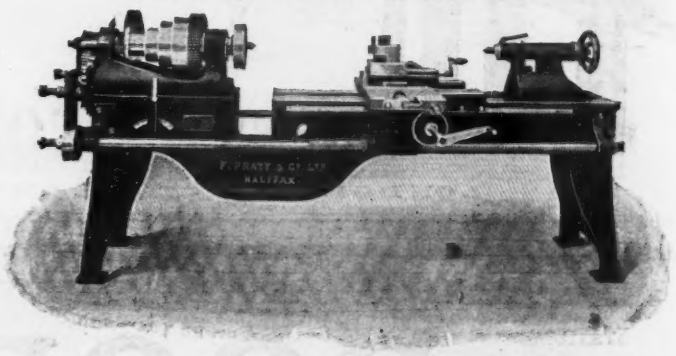

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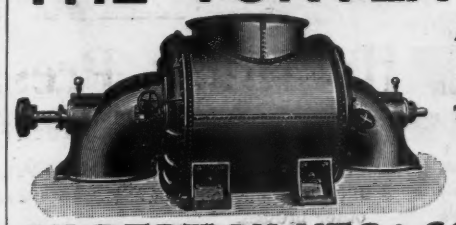

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CELEBRATED

DRAWING INKS

Waterproof.

IN BLACK AND ELEVEN COLOURS.

Also General Non-waterproof and High-class Writing Inks.

NOTE the SPECIAL QUILL for Filling Drawing Instruments.

OF ALL STATIONERS. Y164

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- AUTOMATIC -

Surface Grinding Machines

FOR RAPID AND TRUE WORK ARE UNEQUALLED.

These Labour-saving Machines are indispensable for locomotive and other engine work; also for engineering work generally requiring true surfaces.

GRINDING AND POLISHING MACHINERY

of the most modern designs.

EMERY AND CORUNDUM WHEELS

LUKE & SPENCER, LTD.,

Navigation Works, Broadheath, MANCHESTER. K9

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OVER 200,000 H.P. AT WORK in connection with PULLEYS and WHEELS and as SHAFT COUPLINGS.

PATENT FRICTION CLUTCH.

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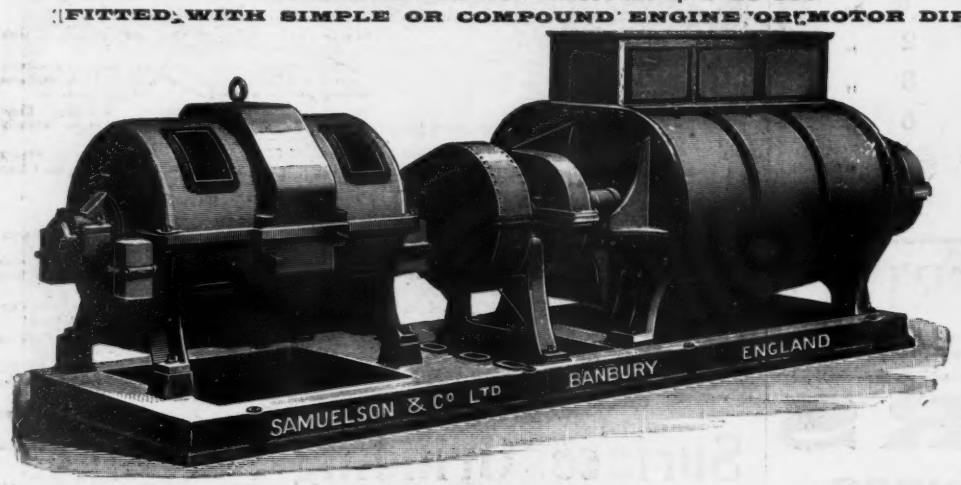
FOR USE WITH ANY MAKE OF CUPOLA, SMITHS' HEARTHS, ALKALI WORKS, &c. &c.

'Acme' Blowers and Gas Exhausters

For ORDINARY and HIGH PRESSURES up to **10 lbs.**

FITTED WITH SIMPLE OR COMPOUND ENGINE OR MOTOR DIRECT.



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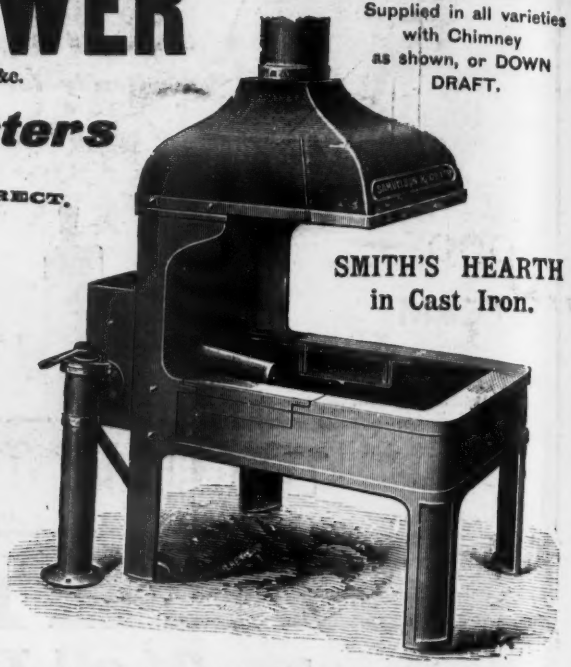

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SAMUELSON & CO., Ltd., BANBURY, ENGLAND.

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IMPROVED "SCHWARTZKOPFF" STOKER. Will burn any variety of Volatile Dust Fuel.

CHEAP small slack, dant, smudge, drosses, duff, washery sludge, &c. &c.

Cheaply converted into—

VALUABLE DUST FUEL

by our PERFECTED PREPARING PLANT and FIRED without smoke in Boilers and Furnaces by our Stokers with—

Highest Efficiency and Economy.

We supply Plans and Estimates of Plant for application to PUDDLING, WELDING, RE-HEATING, ANNEALING FURNACES, &c., Water-tube Cornish, and Lancashire Boilers. T92

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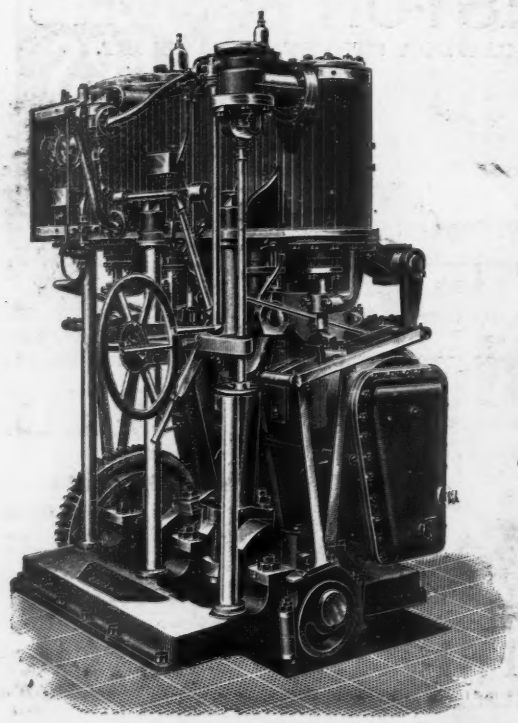

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For SMALL STEAMERS, YACHTS, TUGS, LAUNCHES, TORPEDO BOATS, HOPPER BARGES, &c.

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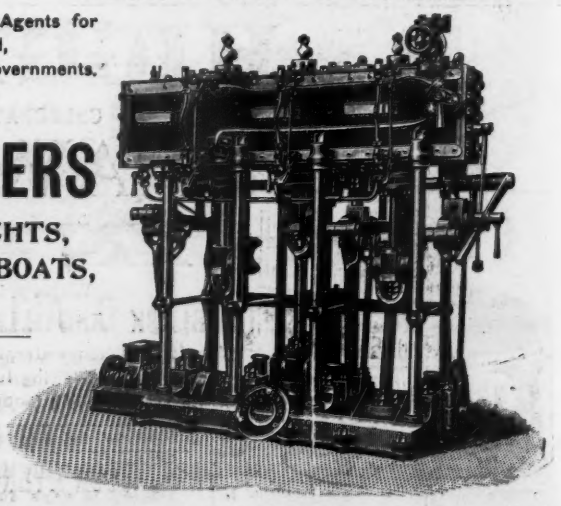

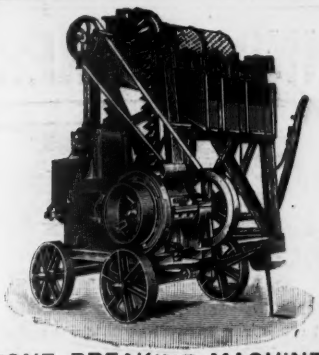

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MASON BROS.,

Brandon Street, LEICESTER, ENGLAND.

Makers of all types of STONEBREAKERS. Thousands now in use. Can be seen working in nearly every town and country in the world. Also makers of a Special Concrete Crusher for Builders, Mortar Mills, Disintegrators, Concrete Mixers, and Grinding Machinery. E5b

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ENGINEERS.

Plans & Estimates Free on application.

Please write for our A1865

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SUMMERSCALES LTD.,

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Feed Water Heaters.

ALL KINDS FOR EXHAUST & LIVE STEAM

POLLOCK, MACNAB & HIGHGATE,

H315 **Shettleston, GLASGOW.**

Stellite Motors.

Q527

See Illustrated Advertisement, page 49, last week.

Graphite Paint.

Q541

CROSIER, STEPHENS & Co.

NEWCASTLE-ON-TYNE

On Admiralty List.

BODLEY BROS. & CO

Engineers, Millwrights, Boiler Makers, and Iron and Brass Founders,

OLD QUAY FOUNDRY, EXETER.

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Machine Moulded.

ALSO

TEETH CUT TO SHAPE

By special machinery.

Telegraphic Address— BODLEY, EXETER

ESTABLISHED 1790.

Gauges.

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The Newall Engineering Co., Ld.,

Warrington. 1015

TEMPERLEY TRANSPORTERS

SAVE TIME & MONEY.

R1342

TEMPERLEY TRANSPORTER CO.

72, Bishopsgate St. Within, LONDON, E.C.

See large illustrated advertisement in issue of Dec. 21

SURVEYING INSTRUMENTS.

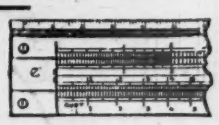
Theodolites. Dials. Levels. Clinometers.

DRAWING INSTRUMENTS.

CELLULOID SLIDE RULES

(Cheap Form.)

Specially constructed for use in Workshops and Offices.



Made in 5in. and 10in. sizes and can be fitted with Magnifying Cursor.

WRITE FOR SUPPLEMENTARY SECTION 0062.

JOHN DAVIS & SON (DERBY), Ltd.,

53, All Saints Works, DERBY.

And 36p, Camomile Street, LONDON, E.C. Z30

LEINERT'S LIQUID METER

(PATENT.)

Automatically measures (by actual weight) water, oils, and other liquids.

Action and all parts visible. Accurate and free from complications.

For full particulars, apply for List 90.

X1921

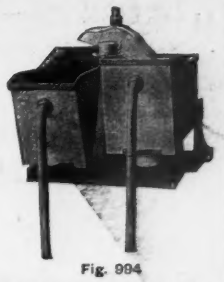


Fig. 994

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SOLE MANUFACTURERS FOR Gt. BRITAIN & COLONIES.

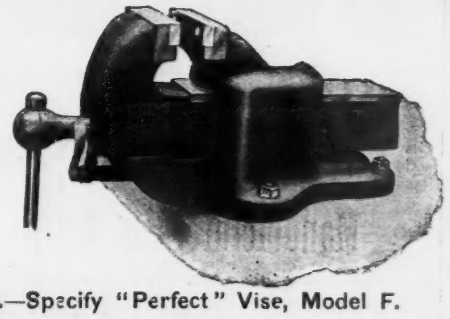
Having WON its WAY by MERIT, and TRIUMPHED on the TIME TEST,

THE # "PERFECT" VISE

in principle UNCHANGED, in construction IMPROVED,

appears as

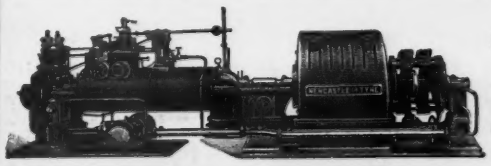
MODEL F.



ADVICE TO BUYERS.—Specify "Perfect" Vise, Model F.

Q457

J. PARKINSON & SON, Shipley, Yorks.



PARSONS & CO.'S

300 k.w. Continuous Current Traction

TURBO GENERATOR.

NEWCASTLE-ON-TYNE, LONDON LEEDS, & GLASGOW. Q245

J. G. ALLEN & CO.

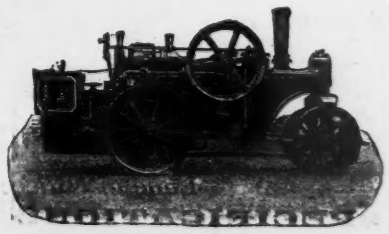
Office—13, College Green, DUBLIN.

Works { **Comber, Co. Down.** **Islandbridge, Dublin.**

PARAFIN OIL ROAD ROLLERS

Economically & Easily Worked.

Carry 12 days' fuel. Require little water. Q469



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Telegraphic Address: **BRITANNIA, MANCHESTER.**

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MANUFACTURERS OF

Machine Tools of the most approved designs, with all essential conveniences.

Milling Machines as follows: PROFILE HORIZONTAL, VERTICAL, UNIVERSAL; sizes of these machines vary from the smallest up to the most massive.

Hure's Patent Universal Milling Machines with two spindles, one to work vertically and the other horizontally.

Alfred Muir's Patent Milling Cutters which remove more material in a given time than any other cutter.

Milling Cutters, ordinary.

Cutter Grinding Machines.

Grinding Machines, self-acting, for external, internal, parallel, or taper work, also cutters.

Hollow Mandrel Lathes, various sizes, with Hole in Mandrel up to 2ft. diameter, Capstan Rest for 3in. square tool or larger.

Special Brass Finishers' Lathes, with Capstan Rest and Guide Screw Chasing arrangement.

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Alfred Muir's Patent Oval Hole and Circular Hole Boring Machines, for Marine Boilers, &c.

Jordan's Patent Multiple Drilling Machine for Boiler Shells and Boiler Flue Rings.

Special Machinery for Ordnance, Small Arms, &c

We have in STOCK or in PROGRESS various sizes and descriptions of the above, also J14

MACHINE TOOLS which are in general demand.

THE

MECHANICAL WOOD WORKER

FOR

Pattern Shops.

See Nov. 30th

T99

WADKIN

AND CO.,

Engineers.

LEICESTER

Agents—Messrs. BUCK & HICKMAN, Ltd., Whitechapel Road, London.

RAILS! RAILS!! RAILS!!!

SEND YOUR ENQUIRIES FOR

RAILS, ACCESSORIES, AND WAGONS

TO

MARPLE & GILLOTT,

Iron and Steel Merchants,

Manufacturers' Constructional Iron Works

CORONATION BUILDINGS, ATTERCLIFFE ROAD, SHEFFIELD

Telephone, 1242. Telegs., "FERRIC," Sheffield.

Z199

RAW HIDE GEARS AND BLANKS

FOR NOISELESS GEARING

AD. AHLERS

SUNDERLAND.

BLAKE PATENT BOILERS,

STEEL RAILWAY WAGONS, RAILWAY WHEELS, BRIDGES, &c.

See Last and Next Week's Advts. Q549

BLAKE BOILER, WAGON & ENG. CO., Ld.,

DARLINGTON.

DRUMMOND BROS., LD.

Small High-Class

LATHES

RYDE'S HILL, near GUILDFORD

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BLAKE, BARCLAY and CO.,

Greenock, N.B. 2015

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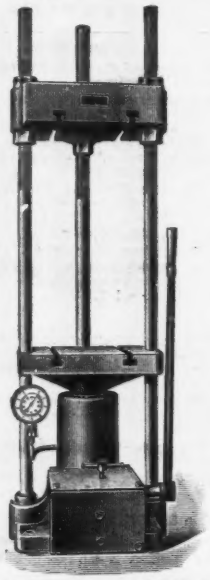
(Speciality) OVER 30 TYPES.



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THE MIRFIELD ENGINEERING Co., Ld.,

MIRFIELD. Z186

AIR COMPRESSORS
VACUUM PUMPS
AIR PUMPS

Steam, Belt, or Motor Driven Pumps

F. W. BRACKETT & Co. HYTHE BRIDGE IRONWORKS, COLCHESTER.

'DRY' VACUUM PUMPS
DONKEY PUMPS
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3-THROW PUMPS

BRUCE & STILL, LTD.,
49, Sefton Street, LIVERPOOL,
Constructional Engineers and Contractors

Iron and Timber Buildings, Roofs, Bridges, Girders, and other constructional work.
Contractors to H.M. Government. Q502
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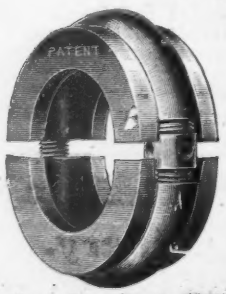
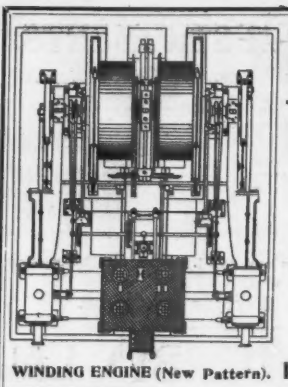
SPIRAL SPRINGS. SPIRAL SPRINGS.
When requiring Spiral or Small Flat Springs or any purpose in connection with your Engines and Machines send your enquiries to
The LION SPRING CO., Oldbury (B'ham),
who are makers to some of the largest Gas Engine and Motor Car Makers, Railway Wagon, Carriage and Tramcar Builders in the World.
See advertisment appearing alternate weeks. Q518

HIGH-CLASS CASTINGS.
Electric & Gas Lamp Pillars.
FEEDER PILLARS and MANHOLES.
SANDWASHERS.
GAS, OIL, AND VACUUM ENGINES
HARDY & PADMORE, Ld., Worcester
Larger Advertisement last and next week. Q515

"SPLIT GRIP"
COLLAR (TRIER'S PATENT)



As USEFUL as he SPLIT PULLEY
IN HALVES.
NO Set Screw to cause Accidents
Grips like a Vice.
Fixed or Removed without Disturbance.
H501
Sole Makers,
TRIER Bros.
Great George Street, WESTMINSTER, LONDON



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WINDING AND HAULING ENGINES.

GRANT, RITCHIE & CO.,
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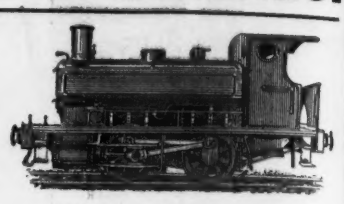
KILMARNOCK, N.B.
ENGINEERS,
IRONFOUNDERS AND BOILERMAKERS.
Locomotives, Pumping Plant,
Corliss & other Winding & Hauling Engines,
Compound Corliss Driving Engines,
Rope Clip Pulleys & Friction Clutches, Mine Fans, Coal Cutters, Coal Cleaning Plant, &c. &c.



TANK LOCOMOTIVE.
Full Particulars, Prices and Specifications on application. 8821

R. LAIDLAW & SON LIMITED,

Telegraphic Codes— A B C 4th Edition. LIEBERS'

GLASGOW.

Telegraphic Address— LAIDLAW, GLASGOW.

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Cast Iron Pipes

For GAS and WATER. From 1in. to 48in. diameter.

Pumping Engines for Waterworks.

VALVES FOR GAS, WATER, & STEAM.

Hydrants, Water Meters, and every other description of Waterworks Plant. Q146

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LONDON OFFICE: 6, LITTLE BUSH LANE, CANNON STREET, E.C.

SILICATE COTTON, ASBESTOS, MAGNESIA,
and other COVERINGS for STEAM PIPES, BOILERS, &c.
Dry Materials specially Compounded and Packed for Export.

"IMPERIAL"
All Asbestos Sectional Pipe Laggings.
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Manufacturers of IRON & STEEL STRUCTURAL & OTHER WORK.

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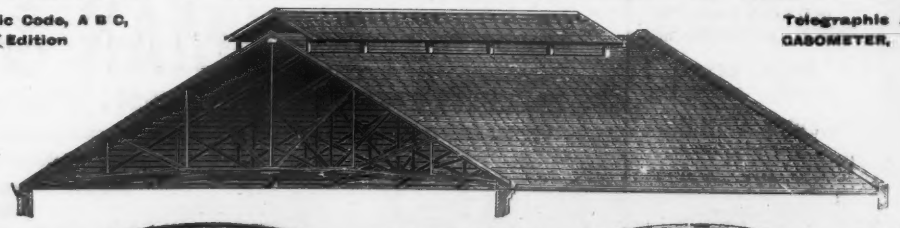

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CASTINGS OF EVERY DESCRIPTION.

Water Towers.
All kinds of
Cast Iron & Steel
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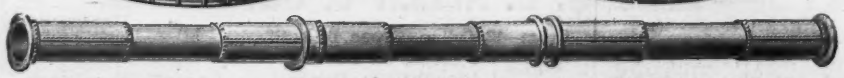

STEEL RIVETTED PIPES WITH FLANGES, SOCKETS, OR COLLARS.

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WINDING ENGINES.

High-class Corliss Engines for Winding & Hauling.

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CONTRACTORS TO HIS MAJESTY'S GOVERNMENT

BRASS & COPPER, LOCO & CONDENSER

TUBES

PLATES & RODS &c&c BIRMINGHAM.

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Hollins Ironworks, Hollinwood, near Manchester.

Speciality:

BRIGHT SHAPED

HEXAGON NUTS

Which for high quality, finish, and lowness of price are unequalled. Guaranteed accurate to Whitworth's Standard. Prices and samples on application. As supplied to Government. W1855

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Shafting, Couplings, &c. &c.

Wood-work Machinery.

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CARBORUNDUM FIRE SAND.

The only perfect refractory material for lining or repairing Furnaces or Ladles.

J. W. JACKMAN & CO.,

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347, Chester Road, MANCHESTER.

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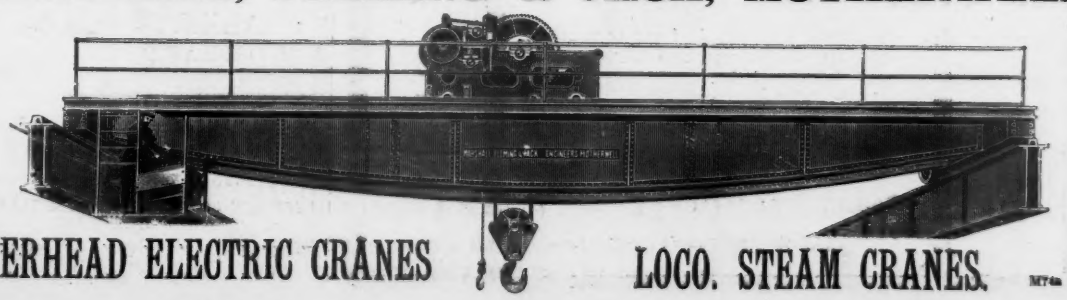
MARSHALL, FLEMING & JACK, MOTHERWELL.



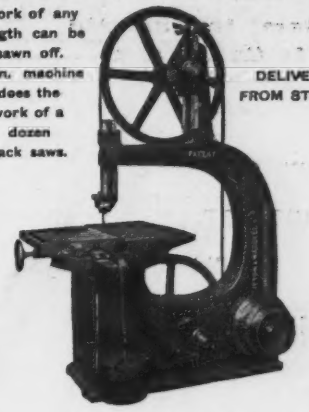
OVERHEAD ELECTRIC CRANES LOCO. STEAM CRANES. M76

CLIFTON & WADDELL,

Metal Sawing Specialists,

JOHNSTONE, nr. GLASGOW.

Work of any length can be sawn off. 30in. machine does the work of a dozen hack saws.



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SPECIALITY— Q269

Patent BAND SAWING MACHINES

Patent Circular Sawing Machines of all kinds for Cutting Iron and Steel.

CHAINS.

WILLIAM DALE.

Ancoats Chain and Testing Works,

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All kinds of WINDING-ON & BACKING-OFF CHAINS for Mules; also CHAINS for Looms, Cranes, Hoists, &c

TREBLE BEST QUALITY.

50 Tons of all Sizes kept in Stock. Q437

TESTS MADE & PROOF CERTIFICATES GIVEN.

Telegrams—Repairs. Telephone—3090.

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EVAPORATORS, HEATERS, FILTERS, CONDENSERS,

AND COMPLETE

Distilling Plants for Ship & Shore Use.

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SAFETY AND WATER RELIEF

Valves.

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Special VALVES for MOTOR CARS

Send for our List 9A, post free. L922

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83, Crutched Friars, LONDON, E.C.

MILEY'S MACHINE TOOL CO.

Worthside Works, Keighley. LTD.,

ADOPT OUR . .

HIGH-SPEED FAST HEADSTOCKS

and make your old Lathes equal to new, with consequent increase of 50 per cent. in your output. Over one hundred supplied and every one giving satisfaction. Please Send us your enquiries. Q496

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THOMAS PARKER LIMITED

ELECTRICAL ENGINEERS AND CONTRACTORS

WOLVERHAMPTON

CONTRACTORS TO WAR OFFICE, ADMIRALTY AND INDIA OFFICE

MOTORS

JOSHUA HEAP & CO.,

ASHTON-UNDER-LYNE. Ld.

PIPE SCREWING MACHINES,

Up to 12in.

BOLT SCREWING & NUT TAPPING MACHINES,

Up to 4in.

CATALOGUE ON REQUEST. Q529

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HALL'S SPECIAL PUMPS

Compound direct-acting. Single-cylinder direct-acting

For Boiler Feeding, Light Service, General Purposes.

ECONOMICAL AND EFFICIENT. Q584

J. P. HALL & SONS, Limited,

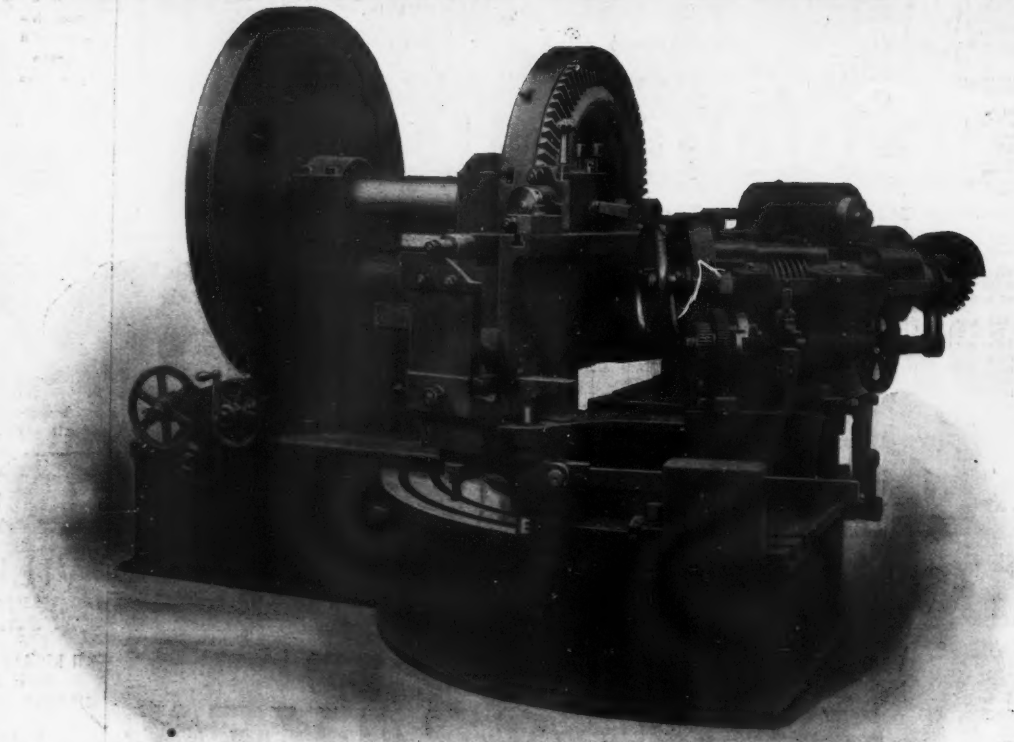
Engineers, PETERBOROUGH.

See larger Advt. last and next week.

One thing needful:
NOISELESS GEARS.
These are ensured by the use of a–

"GLEASON"

Automatic BEVEL GEAR PLANER



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SIZES: 15in. 24in. 36in. and 48in.

SECURE YOUR MACHINE

AGENTS ALSO FOR
Brown & Sharpe,
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LARGE STOCKS.

Ask for our Lists on High-speed Drills and Cutters.

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BRANCHES at Glasgow, Manchester & Birmingham. Telegrams—"ROEBUCK, LONDON." Telphones—7981 CENTRAL (4 lines).

THE LEEDS FORGE CO., LTD., LEEDS.

Builders of
ALL-STEEL FOUR-WHEELED and BOGIE WAGONS
of all capacities
and every description of
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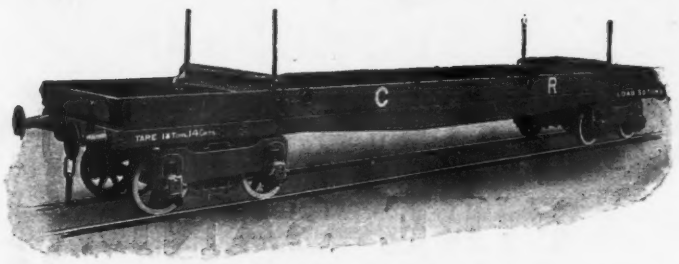

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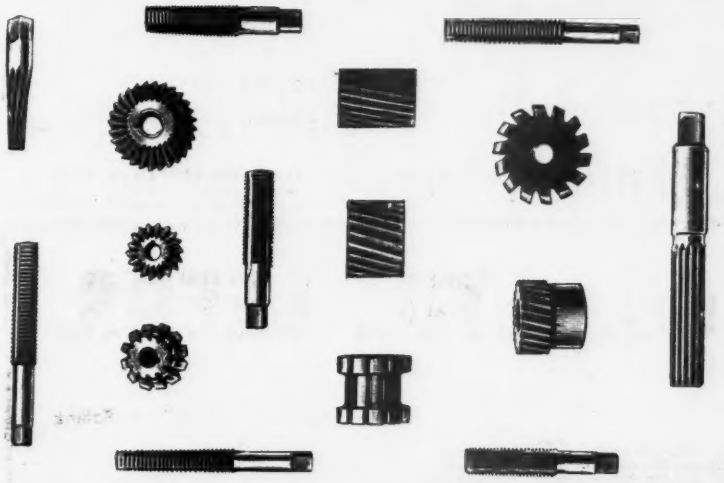

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Blondins and Cableways:
Henderson, J. M., and Co.
Ridgerwood Manufactur g Co

Blowers:
Baker Blower Engineering Co
Drum Engineering Co
Samuelson and Co., Ld
Standard Engineering Co., Ld

Boiler Composition:
Bell's Asbestos Co., Ld

Boiler Composition Feeders:
Smith, S., and Sons, Notts.

Boiler Covering:
Kenyon, W., and Sons
Leroy, F., and Co
United Asbestos Co., Ld

Boiler Insurance:
National Boiler Insurance Co
Vulcan Boiler Insurance Co

Boiler Mountings:
Bailey W. H., and Co., Ld
Galloways Limited
Hartcliffe, Lee & Malkin, Ld
M'Neil, C., jun.

Boilers:
Abbott and Co., Ld
Babcock and Wilcox, Ld
Beeley, T., and Son
Blake Boiler and Wagon Co
Central Marine Engine Works
Cochran and Co., Annan, Ld
Cochrane, Jno.
Coltman, H., and Sons
Davey, Paxman and Co., Ld
Dodman, A., Ld
Farrar, A.
Galloways Limited
Grantham Boiler & Crank Co
Hornsby, R., and Sons, Ld
Lune Valley Engineering Co
Normand's Patents
North-Eastern Marine Engineering Co
Olrick, L., and Co
Plenty and Son, Ld
Ross and Duncan
Rowland, B. R., and Co., Ld
Simpson, Strickland & Co., Ld
Sinclair, Geo.
Spencer, W. H., and Co
Stirling Boiler Co., Ld
Thompson, J.
Thornycroft, J. I., & Co., Ld
Tinker, Shenton and Co., Ld
Tinkers Ld
Yarrow and Co, Ld

Bolts, Nuts, and Fastenings:
Armstrong, Stevens and Son
Baylies, Jones and Baylies, Ld
Lanarkshire Bolt & Rivet Co
Mercer, R.

Books:
Griffin, C., and Co., Ld
Lockwood, Crosby, and Son
Longmans, Green and Co
Spon, E. and F. N., Ld
Whittaker and Co

Brakes:
Vacuum Brake Co., Ld

Brick and Tile Machinery:
Bennett and Sayer
Bradley and Craven, Ld
Brightside Foundry & Eng. Co

Bridges:
Arrol, Sir W., and Co., Ld
Arrol's Bridge & Roof Co., Ld
Bruce and Still, Ld
Clayton, Son and Co., Ld
Cleveland Bridge and Engineering Co
Finch, E., and Co., Ld
Findlay, A., and Co
Handyside and Co., Ld
Horseley Co., Ld
Lysaght, J., Ld
Morton, F., and Co., Ld
Motherwell Bridge Co., Ld
Smith, G. B. and Co
Tees Side Bridge and Engineering Works

Cable (Electric):
Johnson and Phillips

Cable Making Machinery:
Krupp Grusonwerk

Capstans:
Clarke Chapman and Co., Ld

Cask Making Machinery:
Ransome, A., and Co., Ld

Castings:
Allen, E., and Co., Ld
Bradley, T. and W., Ld
Darlington Forge Co., Ld
Haley, E. and W. H.
Hardy Patent Pick Co Ld
Hardy and Padmore, Ld
Herbert, A., Ld
Lilleshall Co
Shaw, W., and Co
Tannett, Walker and Co., Ld
Walker, C and W., Ld

Cement Machinery:
Krupp-Grusonwerk, F.

Cement:
West Kent Portland Cement Co

Centrifugals:
Pott, Cassels and Williamson

Chains:
Dale, William

Coal Hoists, Hydr'c:
Tannett Walker and Co., Ld

Coal and Coke:
Newton, Chambers, & Co., Ld
Talk o'th Hill Colliery, Ld

Coal Cutting Machinery:
Chambers, Scott and Co

Collars, Split Grip:
Trier Brothers

Condensers:
Carrick and Wardale
Cole, Marchent & Morley, Ld
Craig, A. F., and Co., Ld
Edwards Air Pump Syndicate, Ld
Fraser, D., and Sons
Körting Brothers, Ld
Ledward and Beckett, Ld
Mirrlees Watson Co., Ld
Wheeler Condenser Co

Conveyor Belts:
Reddaway, F., and Co., Ld

Conveyors:
Conveyor and Elevator Co
Gilbert Little Co., Ld
Graham, Morton and Co
New Conveyor Co., Ld
Pott, Cassels and Williamson

Cooling Towers:
Balcke and Co
Körting Brothers, Ld

Couplers, Automatic:
Laycock, W. S., Ld

Cranes:
Appleby Ld
Booth, Jos., & Bros. (Rodley)
Broadbent, T., and Sons
Carrick and Wardale
Chaplin, A., and Co
Coles, H. J.
Cowans, Sheldon and Co., Ld
Craven Brothers, Ld
Fielding and Platt, Ld
Gibbins, R. C., and Co
Grafton and Co.
Grieve, J., and Co
Henderson, J. M., and Co.
Higginbottom and Mannock, Isles Ld
Leeds Engg & Hydraulic Co
Marshall, Fleming and Jack
Musker, C. and A., Ld
Ransomes and Rapier, Ld
Roger, R., and Co
Russell, G., and Co
Smith, T., and Sons (Rodley)
Taylor and Hubbard
Temperley Transporter Co
Wilson, J. H., and Co., Ld

Crucibles:
Doulton and Co., Ld

Destructors:
Horsfall Destructor Co., Ld
Meldrum Bros., Ld

Diving Apparatus:
Barnett and Foster
Siebe, Gorman and Co., Ld

Drawings, Tracings, &c.:
Hadley, A.

Dredge Plant:
Ferguson Brothers
Fleming and Ferguson, Ld
Priestman Bros., Ld
Royal Dutch Forge Co
Simons, W., and Co., Ld
Smulders, A. F.

Drop Forgings and Stampings:
Armstrong, Stevens and Son

Drop Hammers:
Brett's Patent Lifter Co., Ld

Electricity:
Allen, W. H., Son & Co., Ld
Bellies and Morcom, Ld
Brit. Westinghouse Electric Co
Bruce Peebles and Co., Ld
Crompton and Co., Ld

Electricity (*continued*)
Dick, Kerr and Co., Ld
Fowler, J., and Co., Ld
Gimson and Co., Ld
Hall, J. P., and Co
Hartnell, W., and Co., Ld
India-rubber, Gutta Percha & Telegraph Works Co., Ld
Industrial Engineering and Motor Co., Ld
Johnson and Phillips
Laurence, Scott and Co., Ld
Mather and Platt, Ld
Parker Thomas, Ld
Royce Limited
Scott and Mountain, Ld
Tangye Tool and Electric Co
Veritys Limited

Elevators:
Conveyor and Elevator Co
Gilbert Little Co., Ld
Graham, Morton and Co
New Conveyor Co., Ld

Emery, Emery Wheels, &c.:
Carborundum Co
London Emery Works Co
Lake and Spencer, Ld
Mitchell's Emery Wheel Co
Oakey, J., and Sons
Rowland, B. R., and Co
Sterne, L., and Co., Ld

Engine & Boiler Fittings, &c.:
Bailey, W. H., and Co., Ld
Bell's Asbestos Co., Ld
Hulburd Engineering Co
Klinger, R., and Co

Evaporators:
Caird and Rayner
Liverpool Engineering and Condenser Co., Ld
Normandy's Fresh Water Co
Royles Limited

Excavators:
Priestman Bros., Ld
Whitaker Brothers, Ld
Wilson, J. H., and Co., Ld

Extinceteurs:
Miller, W.

Fans and Turbines:
Böving, J. Orten
Buffalo Forge Co
Davidson and Co., Ld
Drysdale and Co., Ld
Escher, Wyss and Co., Ld
Gilkes, G., and Co., Ld
Gunther, W., and Sons
Heenan and Froude, Ld
Keith and Blackman Co., Ld
Marsden, John, and Son
Musgrave and Co., Ld
Parsons, C. A., and Co
Parsons Steam Turbine Co
Pitman, P.
Russell, S., and Sons
Thwaites Brothers, Ld
Waddle Patent Fan and Engineering Co

Feed-water Heaters
Holden and Brooke, Ld
Moffatt Lift and Eng. Co., Ld
Weir, G. and J., Ld
Wheeler Condenser and Engineering Co

Fencing:
Baylies, Jones and Baylies, Ld
Rowell, D., and Co

Filters, Waste Oil:
Wells, A. C., and Co

Fireproof Construction:
British Uralite Co., Ld
Trussed Concrete Steel Co

Flexible Couplings:
Boving, J. Orten

Flour Mill Machinery
Turner, E. R. and F.

Forced Draught:
Horsfall Destructor Co., Ld
Howden, J., and Co

Forgings:
Clarke's Crank and Forge Co
Darlington Forge Co., Ld
Grantham Boiler & Crank Co
Hill and Smith
Ihos Forge Co., Ld
Mills, Exors. of J.
Phillips, J., and Co
Rollason, A., and Sons

Foundry Requisites:
Jackman, J. W., and Co

Friction Clutches:
Bridge, D., and Co
Durham, Churchill & Co., Ld
Edmeston, A., and Sons
Longbotham, R. H., and Co
Unbreakable Pulley Co., Ld
Wigglesworth, F., and Co., Ld

Fuel Economisers:
Clay Cross Co
Roberts Bros

Furnaces:
Brown, J., and Co., Ld
Butterley Co., Ld
Deighton's Flue and Tube Co
Leeds Forge Co., Ld
Meldrum Brothers, Ld

Fusible Plugs:
National Boiler and General Insurance Co

Gas:
Dowson Economic Gas Co., Ld
Power Gas Corporation, Ld

Gas Engines:
British Westinghouse Electric and Manufacturing Co., Ld
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Cundall, R., and Sons, Ld
Daniels, T. H. and J., Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons, Ld
Gore Gas Engine Co., Ld
Grice, W., and Sons
Haslam Fdry & Eng'g Co., Ld
Hindley, E. S., and Sons
Hornsby, R., and Sons, Ld
Mather and Platt, Ld
National Gas Engine Co., Ld
Pierson, J. and O. G.
Premier Gas Engine Co., Ld
Robey and Co., Ld
Tangyes Limited

Gauge Glasses
Butterworth Bros., Ld
Guilbert-Martin
Moncrieff, J.
Tomey, J., and Sons, Ld

Gauge Glass Protectors:
Cooper, E., and Co., Ld
Hulburd Engineering Co

Gauges:
Klinger, R., and Co
Negretti and Zambra
Phillips, J. W. and C. J.
Schaffer and Budenberg, Ld

Gear Cutting:
Brown D., and Sons, Ld

Gearing:
Ahlers Ad.
Bodley Brothers and Co
Bowden Patents Syndicate, Ld
Harpers Limited
Reid Gear Co
Unbreakable Pulley Co, Ld

Governors:
Pollock, MacNab & Highgate
Storey, I., and Sons, Ld

Grain Cleaning Machinery:
Boby, R., Ld

Graphite:
Dixon Crucible Co

Grinding Machinery
Bradley Pulveriser Co
Hardy Patent Pick Co, Ld
Phillips, J. W. and C. J.
Roberts Bros
Smedley Bros., Ld

Hammers:
Davis and Primrose
Massey, B. and S.
Piercy and Co., Ld
Player, W. and J.
Pollock, MeNab & Highgate
Ross, R. G., and Son
Thwaites Bros., Ld

Handles:
Burley and Son, Ld

Harbour Plant:
Stothert and Pitt, Ld

Haulage Gear:
Heenan and Froude, Ld
Tickle Bros.

Heating Apparatus:
Buffalo Forge Co
Körting Brothers, Ld
Smith, Howard and Co
Standard Engineering Co., Ld

Hinges, Iron:
Crompton, Thomas

Hose:
Merryweather and Sons, Ld
Moseley, D., and Sons, Ld

Hydraulic Leathers:
Ahlers, A.
Fleming, Birkby and Goodall
Garner Bros

Hydraulic Machinery:
Berry, H., and Co., Ld
Fawcett, Preston and Co. Ld
Fielding and Platt, Ld
Holt and Willetts
Leeds Engineering and Hydraulic Co
Musgrave Bros.
Musker, C. and A., Ld
Rice and Co., Ld
Smith, Hugh, and Co
Tannett, Walker and Co., Ld

Hydro-extractors:
Broadbent, T., and Sons
Manlove, Alliott and Co

Igniter, Gas and Oil Engine:
Lodge Bros. and Co

India-rubber, &c.:
India-rubber, Gutta Percha & Telegraph Works Co., Ld
Moseley, D., and Sons, Ld
Reddaway, F., and Co., Ld

Indicators:
Crosby Steam Gage & Valve Co

Injectors & Ejectors
Davies and Metcalfe, Ld
Green and Boulding, Ld
Gresham and Craven, Ld
Holden and Brooke, Ld
Klinger, R., and Co
Wilcox, W. H., and Co., Ld

Inks, Drawing:
Higgins and Co

Inspect'g Engineers
Clark, J. C.
Price, J.

Insurance:
Railway Passengers Assurance Corporation
Vulcan Boiler Insurance Co

Iron and Steel Works Plant:
Akrill, C., and Co., Ld
Head, Wrightson and Co.,
Jones, George, Ld
Lowca Engineering Co., Ld
Perry, T., and Son Ld

Iron Buildings and Roofs:
Ash, J., and Son
Ashmore, Benson, Pease & Co
Bagshaw, J., and Sons
Barrowfield Ironworks, Ld
Braby, F., and Co
Bruce and Still, Ld
Clyde Structural Iron Co., Ld
Darlington Construction Co
Grover and Co., Ld
Handyside and Co Ld
Heenan & Froude, Ld
Lysaght, J., Ld
Main, A. and J., and Co
Morton, F., and Co., Ld
Piggott, T., and Co., Ld
Rowell, D., and Co
Walker Brothers, Ld

Jointing:
Cooper, E., and Co., Ld
Dixon Crucible Co
Klinger, R., and Co
Moor and Co
Walker, J., and Co

Laundry Machinery:
Bradford, T., and Co
Summerscales, W., and Sons
Tallis, D. and J., Ld

Lifts and Hoists:
Gimson and Co., Ld
Holt and Willetts
Smith and Stevens
Sykes, H., Ld
Waygood, R., and Co., Ld
Youngs

Light:
United Kingdom Lighting Trust
Wells, A. C., and Co

Lithographers
Cook and Hammond

Locks:
Kaye, J. and Sons, Ld

Locomotives:
American Locomotive Co
Avonside Engine Co
Bagnall, W. G., Ld
Beyer, Peacock and Co., Ld
Borsig, A.
Burnham, Williams and Co
Davies and Metcalfe, Ld
Hawthorn, Leslie and Co., Ld
Henschel and Sohn
Hudswell, Clarke and Co
Hunslet Engine Co., Ld
Kerr, Stuart and Co., Ld
Locomotive and Machine Co. of Montreal
Lowca Engineering Co., Ld
Manchester British Locomotive Co., Ld
Peckett and Sons
Stephenson, R., and Co., Ld
Vulcan Locomotive Works

Lubricators:
Hulburd Engineering Co
Hunt and Mitton
Trier Bros.
Wakefield, C. C., and Co

Machine Tools (*see* Tools)

Manganese Steel Castings & Forgings
Allen, E., and Co., Ld
Hadfield's Steel Foundry Co

Marine Machinery:
Renfrew Bros. and Co

Mathematical Instruments:
Davis, J., and Son, Ld
Negretti and Zambra
Stanley, W. F. and Co. Ld

Measuring Machines
Newall Engineering Co., Ld

Merchant Iron:
Dunkerley, C. C., and Co. Ld
Farnley Iron Co., Ld
Henderson and Glass
Henschel and Sohn
Measures Brothers, Ld
Pearson and Knowles Coal Co
Whitehouse, H. B., & Sons, Ld

Metal Perforators:
Barns, W., and Sons

Metals:
Atlas Metal & Alloys Co., Ld
Bull's Metal & Melloid Co., Ld
Delta Metal Co., Ld
Glacier Metal Co., Ld
Phosphor Bronze Co., Ld
Tandem Smelting Syndicate,

Meters:
Glenfield and Kennedy, Ld

Mica:
Wiggins, F. and Sons

Mining Machinery:
Bennis, E., and Co., Ld
Cammell Laird and Co., Ld
Davey, Paxman and Co., Ld
Head, Wrightson and Co., Ld
Robey and Co., Ld
Sandycroft Foundry Co., Ld
Walker Brothers, Wigan

Motor Cars:
Evans, A. G., and Co
Mann's Patent Wagon Co
Nayler and Co., Ld
St Pancras Ironwork Co., Ld
Thornycroft, J. I., & Co., Ld
Yorkshire Steam Wagon Co

Motor Rollers:
Barford and Perkins

Moulding Machines:
Jackman, J. W., and Co

Oil Cans:
Kaye, J., and Sons, Ld

Oil Engines:
Blackstone and Co., Ld
Britannia Engineering Co., Ld
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons
Hornsby and Sons, Ld
Mirrlees Watson Co., Ld
Petter, J. E., and Sons, Ld
Pollock, Whyte and Waddell
Tangyes Limited
Vosper and Co., Ld

Oil Extractors:
Baker's Patent Appliances, Ld
Haigh, W. R., and Co., Ld
Holden and Brooke, Ld

Oil-gas Apparatus:
Mansfield and Sons, Ld

Oil Launches:
Vosper and Co., Ld

Oilless Bushes and Bearings:
Fleming, Birkby & Goodall, Ld

Oil Mill Machinery:
Rose, Downs & Thompson, Ld

Oils and Lubricants:
Price's Patent Candle Co
Snowdon, Sons and Co
Stern-Sonneborn Oil Co
Trier Brothers
Wakefield, C. C., and Co

Packing, Metallic:
Cooper, E., and Co., Ld
Green and Boulding, Ld
Hobdell, Way and Co., L
Hudson, J. & Co., Successors
Hulburd Engineering Co
Klinger, R., and Co
Lancaster and Tonge, Ld
Moseley, D., and Sons, Ld
United Asbestos Co., Ld
U.K. Metallic Packing Synd.
U.S. Metallic Packing Co., Ld
Walker, J., and Co

Paints:
Morris and West

Painting Machines:
Wells, A. C., and Co

Patent Agents:
Alexander, E. P., and Son
Harris and Mills
Jensen and Son
Redfern, G. F., and Co
Roots, J. D., and Co
Vaughan and Son
Watkin, S., Son and Groves

Pattern Makers:
Brown, D., and Sons Ld

Pattern Wood:
Owen J., and Sons Ld

Petrol Motors:
Belsize Motors, Ld

Photo Printing:
Halden, J., and Co

Pig Iron:
Clay Cross Co
Lilleshall Co

Pile Drivers:
Lidgerwood Manuf'g Co
Nasmyth, Wilson and Co., Ld

Pipes, Iron & Steel:
Clayton, Son and Co. Ld
Laidlaw, R., and Son
Meehan and Sons
Piggott, T., and Co., Ld
Stewarts and Lloyds, Ld

Pipe Joints:
Macnaughtan Bros

Pistons:
Lancaster and Tonge, Ld
Lockwood and Carlisle, Ld
Mudd, P. A., and Co

Plates, Steel:
Glasgow Iron & Steel Co., Ld

Plummer Blocks:
Hunt, R., and Co., Ld
Jardine, J.

Pneumatic Tools:
Consolidated Pneumatic Tool Co., Ld
Globe Pneumatic Engineering Co., Ld
Howard Pneumatic Eng'g Co
Industrial Eng'g & Motor Co
Macdonald, J., and Son, Ld
Pneumatic Engineering Appliances Co
Ross, R. G., and Son

Powder Coal Plant
Schwartzkopff Coal Dust Firing Synd.

Presses:
Fawcett, Preston and Co., Ld
Hands, J., and Sons
Mirfield Engineering Co., Ld
Nasmyth, Wilson and Co., Ld
Rhodes, J., and Sons, Ld
Taylor and Challen, Ld

Printing and Stationery:
Reveirs, Geo.

Pulleys:
Bagshaw, J., and Sons, Ld
Garnett, P. and C., Ld
Gimson and Co., Ld
Harpers Limited
Reid, W., and Co
Smith and Grace
Thompson & Southwick, Ld

Pulverisers and Quartz Mills:
Bradley Pulveriser Co
Schwartzkopff Coal Dust Firing Syndicate

Pumps:
Allen, W. H., Son and Co., Ld
Batchelor, R. D.
Brackett, F. W., and Co
Caird and Rayner
Cameron, J., Ld
Carruthers, J. H., and Co
Clarke, Chapman and Co., Ld
Cochrane, John
Drum Engineering Co
Drysdale, J., and Co
Evans, J., and Sons
Fleming and Ferguson, Ld
Glenfield and Kennedy, Ld
Gwynnes Limited
Hall, J. P., and Sons, Peterboro
Hathorn, Davey and Co., Ld
Hayward-Tyler and Co
Hughes and Lancaster
Mumford, A. G., Ld
Owens, S., and Co
Pearn, F., and Co., Ld
Pulsometer Eng'ring Co., Ld
Reader, E., and Sons, Ld
Richards, R., and Co
Simpson, J., and Co., Ld
Tangyes Limited
Thwaites Brothers, Ld
Warner, R., and Co
Westinghouse Brake Co., Ld
Wilcox, W. H., and Co., Ld
Worthington Pump Co., Ld

Pyrometers:
Crompton and Co., Ld

Railway Plant:
Askham Bros. and Wilson, Ld
Bagnall, W. G., Ld
Baker, J., and Co. (Rotherham)
Birch, J. and Co., Ld
Bolling and Lowe
Cammell Laird and Co., Ld
Continuous Rail Joint Co
Cravens, Limited
Dennis, W. F., and Co
Dick, Kerr and Co., Ld
Findlay, A., and Co
Fowler, J., and Co., Ld
Glasgow Railway Engin'g Co
Green, T., and Sons, Ld
Griffith, W., and Sons
Harrison and Camm, Ld
Hudson R.
Isca Foundry Co
Kerr, Stuart and Co., Ld
Koppel, A
Laycock, W. S., Ld
Leeds Forge Co., Ld
Lion Spring Co
Macleilan, P. and W., Ld
Marple and Gillott
Melchinn and Co
Midland Railway Carriage Co
Patent Shaft and Axletree Co
Ransomes and Rapier, Ld
Renshaw, W. R., and Co., Ld
Stableford and Co
Summerson, T., and Sons, Ld
Turner, G. R., Ld
United Electric Car Co., Ld

Rams, Hydraulic:
Blake, J., Ld
Vacher, H. F.

Reducing Valves:
Royles Limited

Refrigerating Machinery:
Farrington Works and H. Pontifex and Sons Ld
Hall, J. and E., Ld
Haslam Foundry and Engineering Co., Ld
Linde British Refrigeration Co
Pulsometer Engineering Co
Sterne, L., and Co. Ld

Rock Drills:
Daw, A. and Z.

Rolls and Rolling Mill Plant
Akrill, C., and Co., Ld
Krupp Grusonwerk, F.

Roofs (*see* Iron Build'gs)

Sand Washers:
Hardy and Padmore, Ld

Saw Mill Machinery (*see* Woodworking Machinery)

Screwing Tackle:
Chatwin, T.
Hulse and Co., Ld
Widdowson, J. H.

Shafting:
Barry, Henry and Co., Ld
Govan Shafting Co
Harpers Limited
Mackies, Ld
Platt, S., Ld
Wigglesworth, F., and Co., Ld.

Shearing Machines:
Jones, Geo., Ld
Perry, T., and Son, Ld

Sheet Metal Work:
Donovan and Co., Ld

Shunting Levers:
Taylor's Patent Shunting Levers

Silencers:
Pratt's, Dukinfield

Soda Water Machinery:
Barnett and Foster

Springs:
Lancaster and Tonge, Ld
Tempered Spring Co., Ld

Steam Engines:
Allan, Anderson and Co
Brazil, Holborow and Straker
Brit. Westinghouse Electric Co
Burrell, C., and Sons
Campbell and Calderwood
Cole, Marchent & Morley Ld
Dodman, A., Ld
Easton and Bessemer, Ld
Galloways Limited
Heenan and Froude, Ld
Hindley, E. S., and Sons
Howden, J., and Co
Lees, T. and R.
Plenty and Son, Ld
Reader, E., and Sons, Ld
Reavell and Co., Ld
Robey and Co., Ld
Ross and Duncan
Royles Limited
Ruston, Proctor and Co., Ld
Samuelson and Co., Ld
Stewart, D., and Co., Ld
Sulzer Bros
Tangyes Limited
Turner, E. R. and F., Ld
Williams and Robinson, Ld
Wilson, A.

Steam Launches:
Cochran and Co., Annan, Ld
Fleming and Ferguson, Ld
Hayes, Ed
Salter, Bros.
Simons, W., and Co., Ld
Simpson, Strickland and Co
Yarrow and Co., Ld

Steam Separators:
Haigh, W. B., and Co
Holden and Brooke, Ld
Lancaster and Tonge, Ld

Steam Traps
Hobdell, Way and Co., Ld
Lancaster and Tonge, Ld
Ransomes, Sims and Jefferies
Smith Bros. (Leicester), Ld

Steel:
Allen, Edgar, and Co., Ld
Armstrong, Whitworth & Co
Boardmore, W., and Co
Brown, Bayley's Steel Works,
Brown, J. and Co., Ld
Butterley Co., Ld
Cammell, Laird and Co., Ld
Carbrook Steel Works
Colville, D., and Sons, Ld
Firth, T., and Sons, Ld
Glasgow Iron & Steel Co., Ld
Hadfield's Steel Foundry Co
Howell and Co., Ld
Jessop, W., and Sons, Sheffield
New Cotehill Works Co
Rogerson, J., and Co
Spencer, J., and Sons
Steel Company of Scotland
Stewarts and Lloyds, Ld
Turton, T., and Son
Vickers, Son and Maxim, Ld

Steel Structural Work:
Ashmore, Benson, Pease & Co
Clayton, Son and Co., Ld
Main, A. and J., and Co
Mechan and Sons, Ld
Morton, F., and Co., Ld

Stills and Distilling Plant:
Blair, Campbell & McLean, Ld
Pontifex and Wood

Stokers, Mechanical, &c.:
Bennis, E., and Co., Ld
Haigh, W. B., and Co
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Proctor, Jas
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